

MISSOURI HAZARD ANALYSIS



Prepared by:

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MEMORANDUM

To: ALL STATE-WIDE HAZARD ANALYSIS HOLDERS

From: JERRY B. UHLMANN, DIRECTOR OF SEMA

This revised Missouri State-wide Hazard Analysis is the result of the collective efforts of all the branches of SEMA. This analysis is an assessment of various risks facing the state and its communities in order to evaluate and rank them. This process is then used to characterize hazards for emergency planning. It estimates the probability of occurrence and the severity of consequences for each hazard and provides a method of comparison.

We are pleased to present the FY '97 State Hazard Analysis in a revised, loose-leaf format which will facilitate future updates of individual hazards within the plan. Each year, we will be forwarding those annexes that required additional revisions or updates, as they are completed by our staff.

State agencies and local jurisdictions should use this hazard analysis for planning, prioritizing, and resource allocation. The information contained herein should identify capabilities essential to disaster response; for determining the probable effectiveness of allocating resources in emergency situations; and for encouraging the cooperation of various political subdivisions and emergency services in formulating regulations, plans and programs in order to mitigate disasters and minimize loss of life, human suffering and damage to public and private property.

RECORD OF CHANGES

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PURPOSE

As we look forward to the 21st century, we can see that the emergency management community faces new and different threats. Gone are the days when emergency management was only for natural disasters and nuclear preparedness. We now face more technologically and politically based hazards that demand the attention of the emergency management community. These new hazards include a number of threats that have not been adequately dealt with in the past, including hazardous materials releases, civil disorders and terrorism.

This document has been compiled to identify the multiplicity of hazards that exist at varying locations and degrees of magnitude throughout the state and to determine the impact these potential hazards would have on residents, property and the environment. The information contained herein should identify capabilities essential to disaster response; for determining the probable effectiveness of allocating resources in emergency situations; and for encouraging the cooperation of various political subdivision and emergency services in formulating regulations, plans and programs in order to mitigate disasters and minimize loss of life, human suffering and damage to public and private property. In addition, a thorough hazard analysis provides a foundation for educating senior government officials and the public on dangers posed by various hazards.

This Hazard Analysis is an assessment of various risks facing the state and its communities in order to evaluate and rank them. This process is then used to characterize hazards for emergency planning. It estimates the probability of occurrence and the severity of consequences for each hazard and provides a method of comparison. The evaluation involves many interrelated variables (i.e., toxicity, demographics, topography, etc.); and should be used in planning and prioritizing allocation of resources by state and local officials.

The hazards presented here are those that have been experienced by or pose a potential threat to Missourians. However, local or isolated problems which constitute a potential disaster should not be overlooked.

The following definitions explain the ratings for each hazard:

Probability--The likelihood or the occurrence of the hazard

Low	Little or no chance of happening.
Moderate	The probability of occurrence is possible.
High	The probability of occurrence is considered sufficiently high as to assume the event will occur.

Severity--The deaths, injuries or damages (property or environmental) that the hazard could create if it occurred

Low	Little or minor damages or injuries if event occurred.
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Moderate Injuries to personnel and damages to the environment and property can be expected.

High Death and major injuries and major damages will occur.

The following is a list of the hazards covered in the analysis and the overall rating they were given by the state:

Tornadoes

Probability - High

Severity - High

Floods (Major and Flash)

Probability - High

Severity - High

Dam Failures

Probability - Low

Severity - Moderate

Drought

Probability - Moderate

Severity - Moderate

Heat Wave

Probability - Moderate

Severity - Moderate

Earthquakes

Probability - High

Severity - High

Severe Winter Weather/Snow

/Ice/Severe Cold

Probability - High (North of Missouri River)

Low (South of Missouri River)

Severity - Moderate (North of Missouri River)

Moderate (South of Missouri River)

Fires (Structural & Urban)

Probability - High

Severity - Moderate

Fires (Wild)

Probability - Moderate

Severity - Low to Moderate

**Attack (Nuclear/Conventional
/Chemical/Biological)**

Probability - Low

Severity - High

Terrorism/Sabotage/Civil Disorder

Probability - Low

Severity - Low to High

Utilities (Interruptions and System Failures)

Probability - High

Severity - Low

Mass Transportation Accidents

Probability - Moderate

Severity - Moderate

**Hazardous Materials (Fixed Facility
Accidents)**

Probability - Moderate

Severity - Moderate

**Hazardous Materials (Transportation
Accidents)**

Probability - High

Severity - Moderate

**Nuclear Power Plants Emergencies
Accidents)**

Probability - Moderate

Severity - Moderate

INTRODUCTION

Missouri's location, in the mid-section of the United States, makes it prone to several kinds of natural hazards. Missouri has a continental climate, i.e., the weather is changeable with large variations in temperature and precipitation.

Missouri serves as the major crossroad of the nation for transportation and has an abundant share of industrial, agricultural and recreational facilities. Thus, the possibility of man-made disasters such as hazardous materials releases, fixed nuclear facility incidents and other human action emergencies does exist.

Missouri can be divided into the four topographically distinct regions: glaciated plains in the north; plains or prairie in the west; lowlands in the extreme southeast; and the Missouri Ozarks in between.

The plains section, both glaciated and unglaciated, encompasses nearly all the area north of the Missouri River and a large area south of the river in the western part of the state. The topography varies from rolling hills in the east to hills in the west that average about 450 feet above sea level. There are numerous wide, flat valleys cut by the river.

The Ozarks, which comprise about half of the state, is a rugged area of sharp ridges and deep narrow valleys. Elevations range from about 1,000 to more than 1,600 feet above sea level.

The southeastern lowlands cover about 3,000 square miles with elevations from 230 to 300 feet above sea level. Much of the region is excellent farmland, drained by an extensive system of drainage ditches.

Situated along two of the continent's greatest rivers, the Missouri and the Mississippi Rivers, the potential for great floods is ever present. While six large flood control dams have been built on the mainstream of the Missouri River, they have not eliminated the flood threat.

Warm and cool air masses collide along sharply divided "fronts," accompanied by violent thunderstorms having intense rains, strong winds, hail and occasional tornadoes. These frontal storm systems can pass across the state at any time of the year, but are most frequent during the spring months (March, April and May).

There is a well worn saying in Missouri about the weather, "If you don't like today's weather, stick around 'cause it'll change." This saying embodies two important truths about Missouri's weather; (1) the state is subject to weather extremes, (2) extreme weather changes can occur rather quickly.

Most of the natural disasters that occur in Missouri (with the exception of earthquakes, land subsidences, and possibly dam failures) are a result of a weather extreme, or an extreme weather change. Since Missouri is situated in the center of the United States, it is subject to many different influences that determine weather patterns.

According to Dr. Grant Darkow ¹, Department of Atmospheric Science at the University of Missouri-Columbia, there are specific recognizable weather patterns that are responsible for Missouri's weather, especially those that "tend to produce extremes in precipitation resulting in unusually wet or drought conditions, and extremes in temperature, either abnormally warm or cold." Darkow explains,

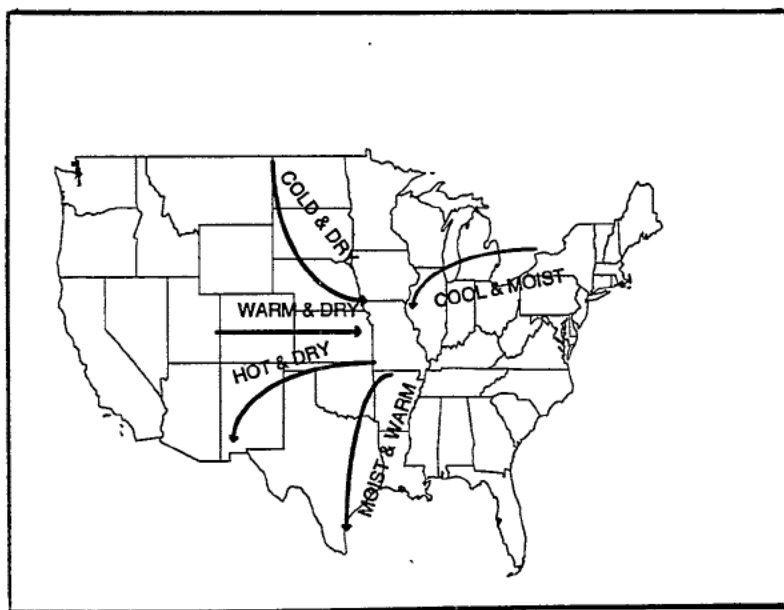
"The character of air over Missouri on any particular day or series of days is dominated by the source regions from which it comes. Missouri's mid-continental location makes it subject to air flows from a variety of source regions with markedly different properties.

The state is close enough to the Gulf of Mexico that warm air with high humidities can flow into the state from a southerly direction at almost any time of the year. This warm, moist air is the principal source of spring, summer and fall precipitation and, occasionally, in winter as well.

In contrast, air arriving over Missouri from semi-arid to arid regions to the southwest is warm or hot and usually dry. Air that has moved from west to east over the Rocky Mountains arrive warm and dry, having lost most of its low-level moisture as it climbed the west side of the mountains.

Abnormally cold air in the winter and cold summer air with only very small moisture content arrives over Missouri from the northwest or north, whereas air entering Missouri from the northeast will tend to be cool and moist." (Figure 1.)

Figure 1. Source regions and atmospheric characteristics for air arriving in Missouri.



Darkow goes on to explain,

"Normally, the flow from one of the principal source regions will last for two or three days before switching to a different direction and source region. These transitions

¹ Grant L. Darkow, Missouri Weather Patterns and Their Impact on Agriculture, University Extension, University of Missouri-Columbia.

typically are accompanied by a frontal passage during which the change in wind direction, temperature, and moisture content, or any combination, is concentrated.

In some instances, however, a particular flow pattern may be very persistent or dominant for a period of weeks or even months. These periods can lead to wet, dry, hot, or cold spells, and the extremes associated with these periods. These periods are characterized by particular upper air flow patterns and associated surface weather patterns.” (See Figures 3a, 3b, 4a, 4b, 5a, 5b)

Figure 3a. Upper Air Pattern (Precipitation Producing).

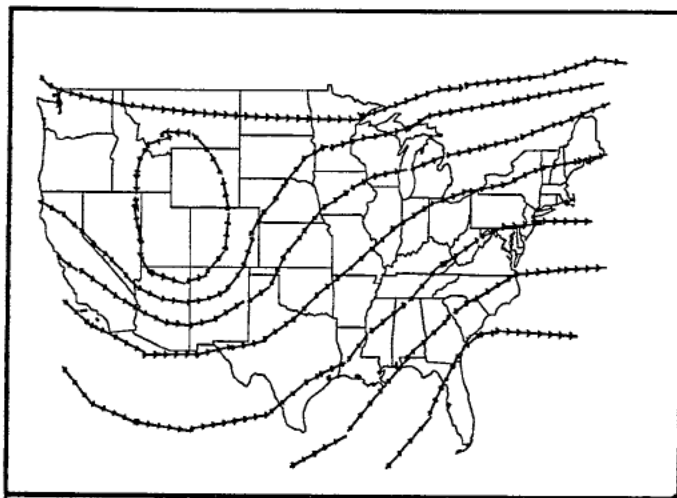


Figure 3b. Surface (Precipitation Producing).

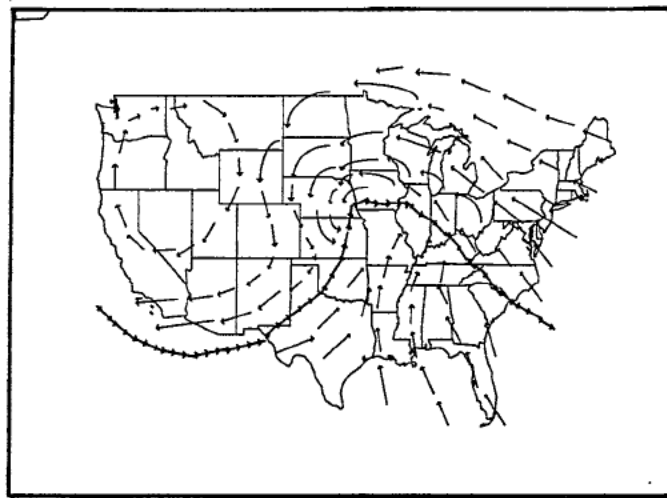


Figure 4a. Upper air pattern (dry to drought producing).

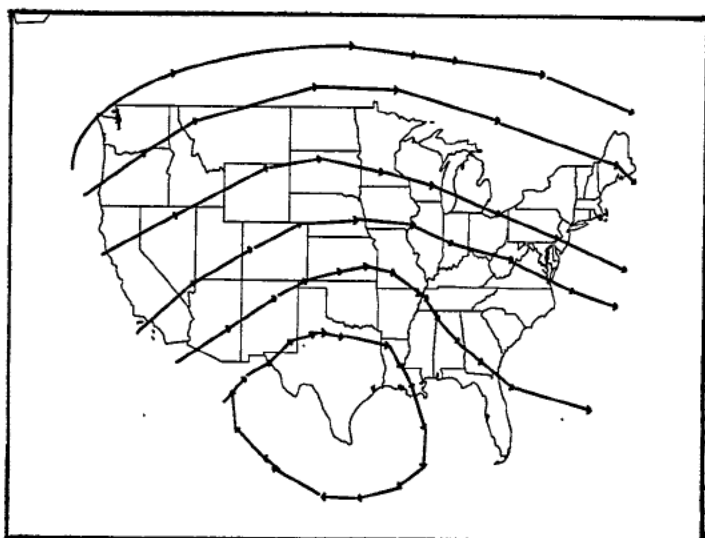


Figure 4b. Surface pattern (dry to drought producing).

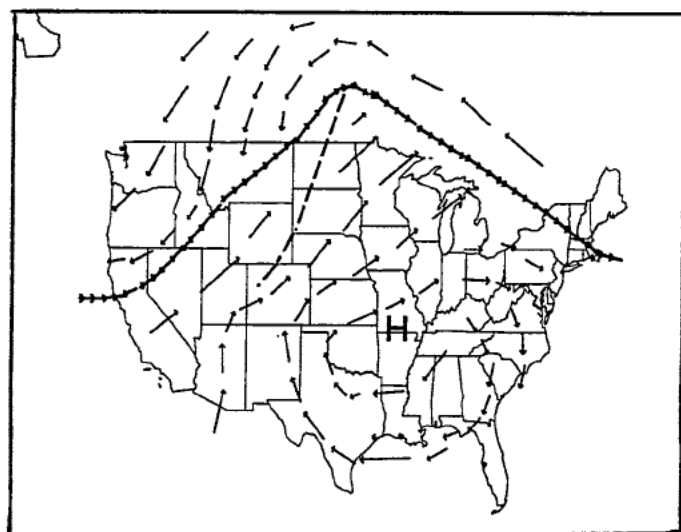


Figure 5a. Upper Air Pattern (cold-dry case).

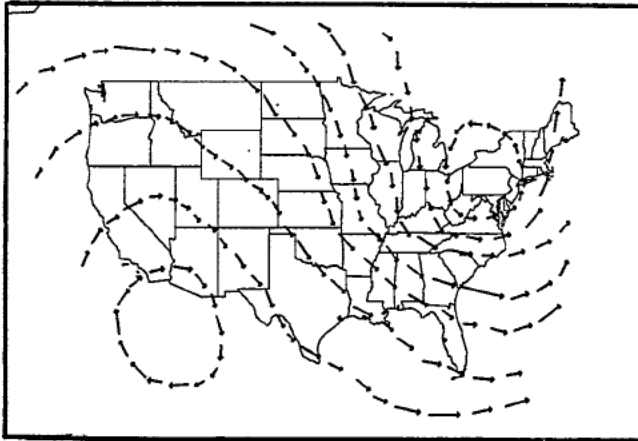
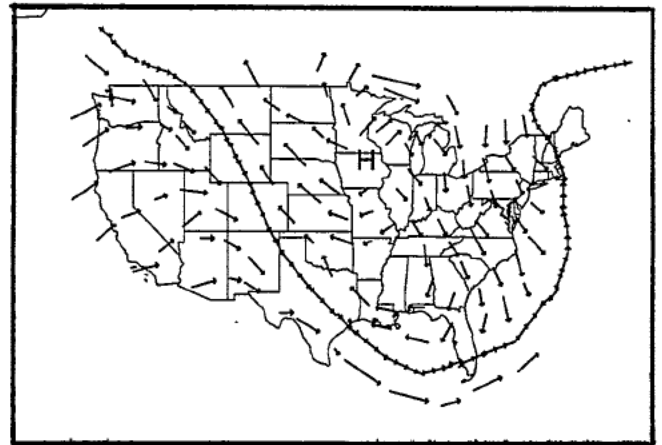


Figure 5b. Surface pattern (cold-dry case).



“The persistence of these weather patterns, and the possible resulting condition is the subject of several of the natural disasters discussed in this study. Specifically, floods, droughts, fires, heat waves, severe cold and winterstorms can be the result of the persistence of one of these weather patterns, whereas tornadoes can represent the outgrowth of rapid shifts in weather patterns. Knowing these patterns may assist in alerting disaster planners and the general public to the possibility of a developing emergency situation.”

The Missouri State Emergency Operations Plan (1995) considers the following types of disasters:

NATURAL DISASTERS: Natural disasters can be complex, occurring with a wide range of intensities. Some events are instantaneous and offer no window of warning, such as earthquakes. Some offer a short window in which to alert the public to take actions, such as tornadoes or severe thunderstorms. Others occur less frequently and are typically more expansive, with some warning time to allow the public time to prepare, such as flooding. The following is a list of natural disasters prevalent to Missouri:

- Tornadoes
- Floods (Major and Flash)
- Water (Interruptions and Drought)
- Earthquakes/Land Subsidence
- Wild Fires (Forest, Prairie, and Grasslands)
- Winter Storms and Severe Cold
- Heat Wave
- Severe Weather

MAN-MADE DISASTERS: Each year there is an increase in man-made incidents which can be just as devastating as natural disasters. The following is a list of man-made disasters that could affect the State of Missouri:

- Structural and Urban Fires
- Utilities (Interruptions and Failures)
- Fixed Facility and Transportation Nuclear Hazards
- Hazardous Materials; Other Environmental Issues
- Mass Transportation Incident
- Nuclear Attack
- Conventional Attack
- Biological and Chemical Attack
- Terrorism
- Sabotage
- Civil Disorder
- Dam Failure

This hazard analysis will deal only with these indicated disasters.

In the United States, 95 percent of all Presidentially-declared disasters are weather or flood related natural events. In Missouri, 100 percent of the Presidentially-declared disasters since 1975 are also weather or flood related. Table 1 is a summary of Presidentially-declared disaster for Missouri since 1975. Under Type of Assistance, IA denotes Individual Assistance, while PA denotes Public Assistance.

Table 1. Presidential Declarations for Missouri Since 1975

Declaration Date	Incident Type	# of Counties Designated	Type of Assistance By County
May 3, 1975	Tornadoes, High Winds and Hail	4	IA & PA - 4
July 21, 1976	Severe Storms and Flooding	4	IA & PA - 4
Sept. 24, 1976	Drought	94	PA Only - 94
May 7, 1977	Tornadoes, Flooding	7	IA & PA - 7

Declaration Date	Incident Type	# of Counties Designated	Type of Assistance By County
Sept. 14, 1977	Severe Storms and Flooding	6	IA & PA - 6
March 12, 1979	Ice Jam, Flooding	2	PA Only - 2
April 21, 1979	Tornadoes, Torrential Rains & Flooding	17	IA Only - 1 IA & PA - 16
May 15, 1980	Severe Storms & Tornadoes	1	IA Only - 1
Aug. 26, 1982	Severe Storms & Flooding	3	IA Only - 1 IA & PA - 2
Dec. 10, 1982	Severe Storms & Flooding	17	IA Only - 8 PA Only - 1 IA & PA - 5
June 21, 1984	Severe Storms & Flooding	11	IA Only - 1 PA Only - 8 IA & PA - 2
Oct. 14, 1986	Severe Storms & Flooding	30	IA Only - 7 PA Only - 15 IA & PA - 8
May 24, 1990	Severe Storms & Flooding	10	IA Only - 2 IA & PA - 8
May 11, 1993	Severe Storms & Flooding	8	IA Only - 8
July 9, 1993	Severe Storms & Flooding	102	IA Only - 14 IA & PA - 88 (Cities) IA & PA - 3

Declaration Date	Incident Type	# of Counties Designated	Type of Assistance By County
Dec. 1, 1993	Severe Storms, Tornadoes and Flooding	24	IA Only - 10 IA and PA - 14
April 21, 1994	Severe Storms, Tornadoes and Flooding	18	IA Only - 18
June 2, 1995	Severe Storms, Tornadoes and Flooding	61	IA Only - 18 (Cities) IA Only - 1 IA & PA - 43

Table 2 shows the total eligible amount for Public Assistance disaster declarations in Missouri from 1990-1995. Public Assistance provides state/federal assistance for uninsured losses to public property and infrastructure within those counties included in the disaster declaration.

Table 2. Public Assistance for Missouri Flood Disasters, 1990-1995

Date	DR#	Number of Applicants	Damage Survey Reports	Total Amount Eligible
Spring 1990	0867	72	2,023	\$9,461,555
Summer 1993	0995	901	14,392*	\$138,172,058*
Fall 1993	1006	38	563*	\$3,398,710*
Spring 1995	1054	329	2,246*	\$16,170,240*
TOTALS		1,340	19,224*	\$167,202,563*

*Figures as of April, 1997

Table 3 shows the total amount of Individual Assistance for IA declared disasters in Missouri from 1990-1995. Individual Assistance provides state/federal assistance to individuals and families for uninsured losses within those counties included in the disaster declaration.

Table 3. Individual Assistance for Missouri Flood Disaster, 1990-1995

Date	DR #	Individual Assistance	Total Number of Applicants
Spring 1990	867	\$4,000,000	700
Spring 1993	989	\$1,591,241	447
Summer 1993	995	\$65,690,976	15,478
Nov. 1993	1006	\$2,796,562	673
Spring 1994	1023	\$2,116,639	779
Spring 1995	1054	\$4,297,039	1,868
TOTALS		\$78,902,807	19,945

Table 4 shows the total projected Federal expenditures through September 30, 1994 for four major disasters.

Table 4. Federal Disaster Expenditures

Disaster Incidents	Declaration Date	Projected Federal Expenditures (in Millions of Dollars)
Hurricane Andrew	August 1992	3937.1
Hurricane Iniki	September 1992	554.2
Midwest Floods	Summer 1993	6011.7
Northridge Earthquake	January 1994	3714.6*

* Note that this column represents expenditures through September 30, 1994 and some, especially in the case of Northridge Earthquake, will increase.

FOREWORD

Lately, disasters appear to be occurring on a more frequent basis than during previous years. Federal, State and local emergency managers need to prepare for, respond to and recover from the increasing frequency and scope of disasters. While recent major disasters are memorable, the increased rate of occurrence is remarkable. Disasters in the 1980's were nearly twice as frequent as disasters in the 1970's. From 1993-1995 alone, Missouri has experienced five flood disasters, including one which exceeded the once in every 500 years flood levels. According to some weather forecasters, the country has entered a period of extremely destructive weather patterns.

The foundation in emergency preparedness is planning how to handle disasters. The art of perfecting how to respond to disasters is enhanced by the ability to bring together the key players for periodic exercises which stimulate actual disasters.

This Hazard Analysis should be used in planning and allocation prioritizing by state and local officials. Local officials can utilize this document to develop their own localized hazard analysis.

POPULATION

Missouri has a surface land area of 68,995 square miles with a population of 5,117,073 (1990 census).

Missouri ranks fifteenth among the fifty states in population; eighteenth in land area and twenty-seventh in population density. There are 960 incorporated cities, towns, and villages in the state.

In 1830, the first year in which Missouri was enumerated as a state, it had a population of 140,455. The 1970 census showed 4,677,623 inhabitants; and in the 1980 census, there were 4,917,444 residents; in 1990, the census indicated another increase of people to 5,117,073.

The population center of the United States continues to inch westward and is currently located a quarter mile west of the City of DeSoto, Missouri.

Missouri Population	5,117,073
Area Square Miles	68,995
Population Equivalent per square mile	67.79
Number of incorporated cities, towns and villages	960
Number of Counties	114
Urban Population	70%
Metropolitan Population	64% of total urban population
Cities with a population of 50,000 or more	5
Counties with population of 1/2 million or over (St. Louis and Jackson)	2
Counties with population of 100,000 to 200,000 (Clay, Greene and Jefferson)	3
Counties with population of 50,000 to 100,000 (Boone, Buchanan, Franklin, Pulaski and St. Charles)	5
Counties with a population of 25,000 to 50,000	25

Counties with a population of 15,000 to 25,000	25
Counties with a population of 10,000 to 15,000	23
Counties with a population of 1 to 10,000	32

Ten of the 114 counties or 8.77 percent represent over 74 percent of the total population; two of these ten (St. Louis and Jackson counties), contain 34 percent of the state's total population.

Approximately two million employees earn their living in Missouri. Each year more than 30,000 new high school graduates enter the state's labor market.

HAZARDS

**TORNADOES/SEVERE
THUNDERSTORMS
(DOWNBURSTS, LIGHTNING,
HAIL, HEAVY RAINS, WIND)**

I. TYPE OF HAZARD

Tornadoes/Severe Thunderstorms
(Downbursts, Lightning, Hail, Heavy Rains, Wind)

II. DESCRIPTION OF HAZARD

Tornadoes are cyclical windstorms often associated with the midwestern areas of the United States. Weather conditions which are conducive to tornadoes often produce a wide range of other dangerous storm activities, including severe thunderstorms, downbursts, straight line winds, lightning, hail, and heavy rains. For the purpose of this analysis, tornadoes will be considered in one category. Other severe weather activities, noted above, are referenced separately in the Synopsis section of this annex (see Part VI).

Essentially, tornadoes are a vortex storm with two components of winds. The first is the rotational winds that can measure up to 500 miles an hour and the second is an uplifting current of great strength. The dynamic strength of both these currents can cause vacuums that can overpressure structures from the inside. Although tornadoes have been documented in all fifty states, most of them occur in the central United States. The unique geography of the central United States allows for the development of the thunderstorms that spawn tornadoes. The jet stream, which is a high velocity stream of air, determines which area of the central United States will be prone to tornado development. The jet stream normally separates the cold of the north from the warm of the south. During the winter, the jet stream flows west to east over Texas to the Carolina coast. As the sun "moves" north, so does the jet stream, which at summer solstice flows from Canada across Lake Superior to Maine. During its move north in the spring and its recession south during the fall, it crosses Missouri causing the large thunderstorms that breed tornadoes.

Tornadoes spawn from the largest thunderstorms. These cumulonimbus clouds can reach heights of up to 55,000 feet above ground level, and are commonly formed when warm, gulf air is warmed by solar heating. The moist warm air is overridden by the dry cool air provided by the jet stream. This cold air presses down on the warm air preventing it from rising, but only temporarily. Soon, the warm air forces its way through the cool air and the cool air moves downward past the rising warm air. Adding to all this is the deflection of the earth's surface, and the air masses will start rotating. This rotational movement around the location of the breakthrough forms a vortex, or funnel. If the newly created funnel stays in the sky, it is referred to as a funnel cloud. However, if it touches the ground, the funnel officially becomes a tornado.

A typical tornado can be described as a funnel shaped cloud that is "anchored" to a cloud, usually a cumulonimbus, that is also in contact with the earth's surface. This contact is, on the average, for 30 minutes and covers an average distance of 15 miles. The width of the tornado (and its path of destruction) is usually about 300 yards wide. However, tornadoes can stay on the ground for upward of 300 miles and can be up to a mile wide. The National Weather Service, in reviewing tornadoes occurring in Missouri between 1950 and 1996, calculated the mean path length was 2.27 miles and the mean path area was 0.14 square miles.

The average forward speed of a tornado is 30 miles per hour but may vary from nearly stationary to 70 miles per hour. The average tornado moves from southwest to northeast, but tornadoes have been known to move in any direction. Tornadoes are most likely to occur between 3 and 9 in the afternoon and evening, but have been known to occur at all hours of the day or night. The following chart shows the hourly distribution of tornadoes in Missouri (1950 - 1996):

Table 1

INITIAL TOUCHDOWN

MONTH	TIME (In LST: All P.M.)
January	2:31
February	11:06
March	7:49
April	5:39
May	5:46
June	6:01
July	5:16
August	4:48
September	5:05
October	4:51
November	4:11
December	8:24

Mean Time

5:49

Tornadoes are classified according to the F- Scale (developed by Dr.Theodore Fujita, a renowned severe storm researcher). The F- Scale attempts to rank tornadoes according to wind speed based on the damage caused.

Table 2

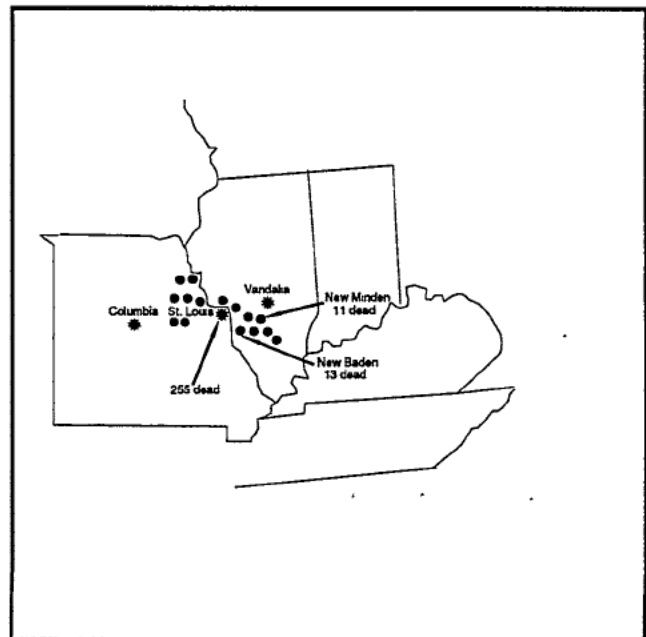
F- Scale Speed in MPH		Missouri Tornadoes By F - Scale Since 1950	
F 0:	40 - 72	F 0:	47%
F 1:	73 - 112	F 1:	24%
F 2:	113 - 157	F 2:	16%
F 3:	158 - 206	F 3:	12%
F 4:	207 - 260	F 4:	1%
F 5:	261 - 318	F 5:	0%

III. HISTORICAL STATISTICS

Historically, the state of Missouri has experienced numerous tornadoes of varied intensities. On May 27, 1896, between the hours of 2 and 8 p.m., a series of 18 tornadoes known as the "St. Louis, Missouri Outbreak" struck Missouri and Illinois. These tornadoes resulted in 306 deaths and \$15 million in damages.

A United States Weather Service study showed that, from 1916 through 1949, Missouri had recorded 237 tornadoes with 458 deaths and \$ 44,399,400 worth of damages. This resulted in an average of 6.9 tornadoes per year and an average of 130 deaths per year. The statistics from 1916 through 1996 show that Missouri has incurred 615 deaths from tornadoes.

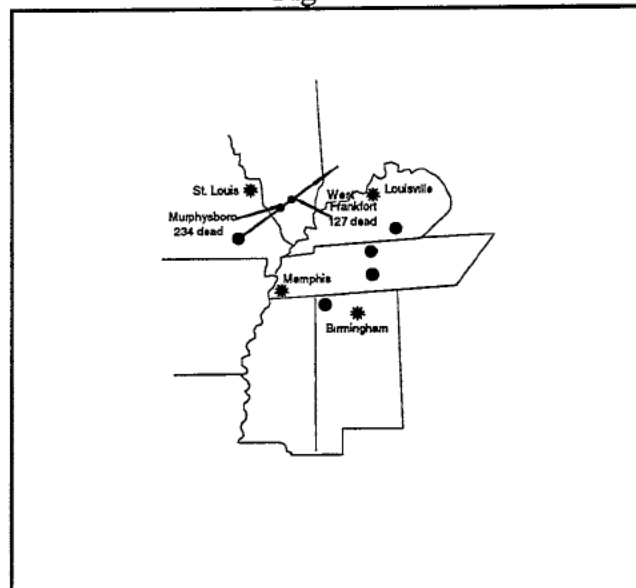
Figure 1



The worst tornado in United States history, to that date, in terms of death and destruction occurred on March 18, 1925, between 1 and 6 p.m. The great "tri-state" tornado originated in Reynolds County. It proceeded east northeast through 1/4 of Illinois into Indiana, covering 219 miles. It caused over \$18 million damage, affected six states, and killed 689 persons.

The City of Poplar Bluff was almost wiped out by a tornado on May 9, 1927. This tornado cost 92 lives and \$2 million in damages. The same day, two severe tornadoes struck St. Louis, Missouri. The first tornado moved across the entire city from the western city limits to the Mississippi River through the Lafayette Park section killing 306 people in Missouri and Illinois and causing almost \$13 million in damages. The second tornado started in the southwestern part of the city and proceeded through the Tower Grove and Vanderventer sections, then on to Granite City, Illinois. Seventy-nine people were killed and about \$23 million in damages resulted from this storm.

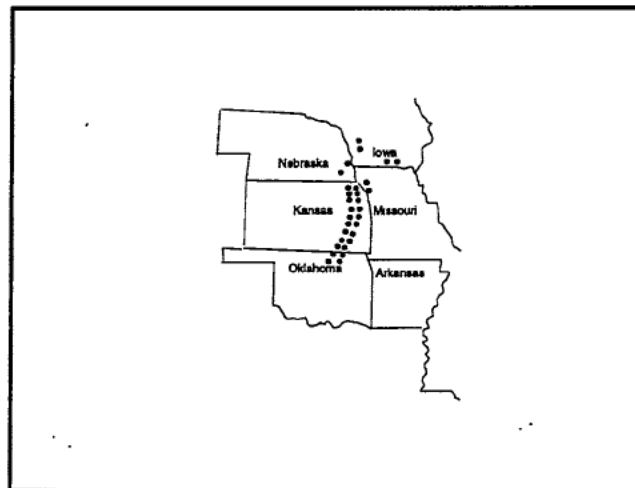
Figure 2



During the afternoon and evening of April 3, and the early morning of April 4, 1974, a "super outbreak" of 148 tornadoes across 13 states killed more than 300 people, injured more than 6,000 and caused \$600 million in damages.

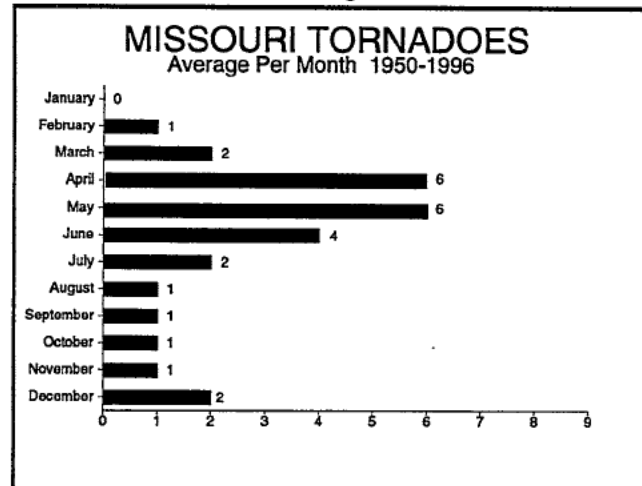
On the afternoon of April 26, and the early morning of April 27, 1991, an outbreak of 54 tornadoes covering six states, including Missouri, resulted in 21 deaths, 308 injuries, and damages exceeding \$277 million. There were two deaths in vehicles and 15 in and near mobile homes.

Figure 3



On July 4, 1995 at approximately 5:40 P.M. a tornado struck the Randolph County community of Moberly. The initial touchdown of the storm was south of town. The storm then moved through the eastern half of the community. The tornado uplifted approximately seven (7) miles northeast of Moberly. At least 15 people were injured, 25 businesses damaged, along with the Courthouse, and some 300 families affected. This resulted in a Small Business Administration disaster declaration for low interest loans. The tornado was characterized as a class (F3) tornado by the National Weather Service.

Figure 4



IV. MEASURE OF PROBABILITY AND SEVERITY

There are 10 times more tornadoes in the United States than any other nation in the world. Missouri averages 26 tornadoes per year, and has recorded 1,229 tornadoes from 1950-1996. **Missourians have a high probability that tornadoes will continue to affect their lives.** The natural phenomena which create tornadoes will continue to occur beyond our ability to control them.

The enormous power and destructive capability of tornadoes are beyond mankind's capabilities to control. **The severity of the effects of a tornado will continue to be high.** We will continue to experience deaths, injuries, and property damages as a result of these phenomena. However, technological advances will facilitate earlier warning than previously available. This, combined with a vigorous public education program and improved construction techniques, provide the potential for significant reductions in the number of deaths and injuries as well as a reduction in property damage.

V. IMPACT OF THE HAZARD

Every tornado is a potential killer and many are capable of great destruction. Tornadoes can topple buildings, roll mobile homes, uproot trees, hurl people and animals through the air for hundreds of yards, and fill the air with lethal, windblown debris. Sticks, glass, roofing material, and lawn furniture all become deadly missiles when driven by a tornado's winds. In 1975, a Mississippi tornado carried a home freezer for more than a mile. Once a tornado in Broken Bow, Oklahoma, carried a motel sign 30 miles and dropped it in Arkansas! Tornadoes do their destructive work through the combined action of their strong rotary winds and the impact of windblown debris. In the most simple case, the force of the tornado's winds push the windward wall of a building inward. The roof is lifted up and the other walls fall outward. Until recently, this damage pattern led to the incorrect belief that the structure had exploded as a result of the atmospheric pressure drop associated with the tornado.

VI. SYNOPSIS

Tornadoes are usually associated with severe thunderstorms, which by themselves, possess their own destructive potential. Such storms most often occur in the spring and summer, during the afternoon and evenings, but can occur at any time. In addition to tornadoes, other hazards associated with thunderstorms include:

- Damaging Winds
- Lightning and resulting fires
- Hail
- Heavy rains causing flash flooding

The damaging winds of thunderstorms include downbursts, micro bursts, and straight line winds. Downbursts are localized currents of air blasting down from a thunderstorm, which induce an outward burst of damaging wind on or near the ground. Microbursts are minimized downbursts covering an area of less than 2.5 miles across. They include a strong wind shear (a rapid change in the direction of wind over a short distance) near the surface. Micro bursts may or may not include precipitation and can produce winds over 150 miles per hour.

In May 1996, a Memorial weekend storm identified by the National Weather Service as a micro burst caused more than \$10 million damage to homes in Lee's Summit, Missouri. The storm destroyed at least 13 homes and damaged more than 100 others in several Lee's Summit subdivisions. The city also incurred a substantial cost for debris removal and cleanup activities as a result of this devastating storm.

Damaging straight-line winds are high winds across a wide area which can reach speeds of 140 miles per hour. Large hail can reach the size of grapefruit. Hail causes several hundred million dollars in damage annually to property and crops across the nation. Lightning kills 75 - 100 people each year. During the period 1992 - 1996, seven people died in Missouri as the result of lightning strikes. There were two deaths as the result of tornadoes during the same period! The thunderstorms associated with tornado development also contribute to the **number one weather killer - flash floods!** Flash flooding causes 146 deaths annually throughout the nation. During the period from 1992 - 1996, flooding and flash floods claimed the lives of 45 Missourians. Thunderstorms and severe winds claimed five lives over this same period.

Although not as common, waterspouts are weak tornadoes that form over warm water. Waterspouts are most common along the Gulf Coast and Southeastern states. In the Western United States, they occur with cold late fall or late winter storms, during a time when you least expect tornado development. Waterspouts occasionally move inland becoming tornadoes causing damage and injuries.

Tornadoes occasionally accompany tropical storms and hurricanes that move over land. Tornadoes are most common to the right and ahead of the path of the storm center as it comes ashore.

VII. MAPS OR OTHER ATTACHMENTS

The following charts and maps depict additional Missouri tornado information, generally for the period 1950 - 1996:

Table 3

DISASTER DECLARATIONS FOR MISSOURI TORNADOES SINCE 1975

Date	Incident Type	Counties Declared	Type of Assistance
May 3, 1975	Tornadoes, High Winds, Hail	Caldwell	PA & IA
		Newton	PA & IA
		Macon	PA & IA
		Shelby	PA & IA
May 7, 1977	Tornadoes & Flooding	Carroll	PA & IA
		Clay	PA & IA
		Lafayette	PA & IA
		Ray	PA & IA
		Cass	PA & IA
		Jackson	PA & IA
		Pettis	PA & IA
May 15, 1980	Severe Storms & Tornadoes	Pettis	IA Only
May 1986	Tornadoes	Scott	SBA Loans
		Mississippi	SBA Loans
		Cape Girardeau	SBA Loans
		Perry	SBA Loans
Nov. 1988	Tornadoes	St. Charles	SBA Loans
		Barry	SBA Loans
July 1995	Tornadoes	Randolph	SBA Loans
		(City of Moberly)	SBA Loans

PA - denotes Public Assistance

IA - denotes Individual Assistance

SBA - denotes Small Business Administration Loans

Figure 5

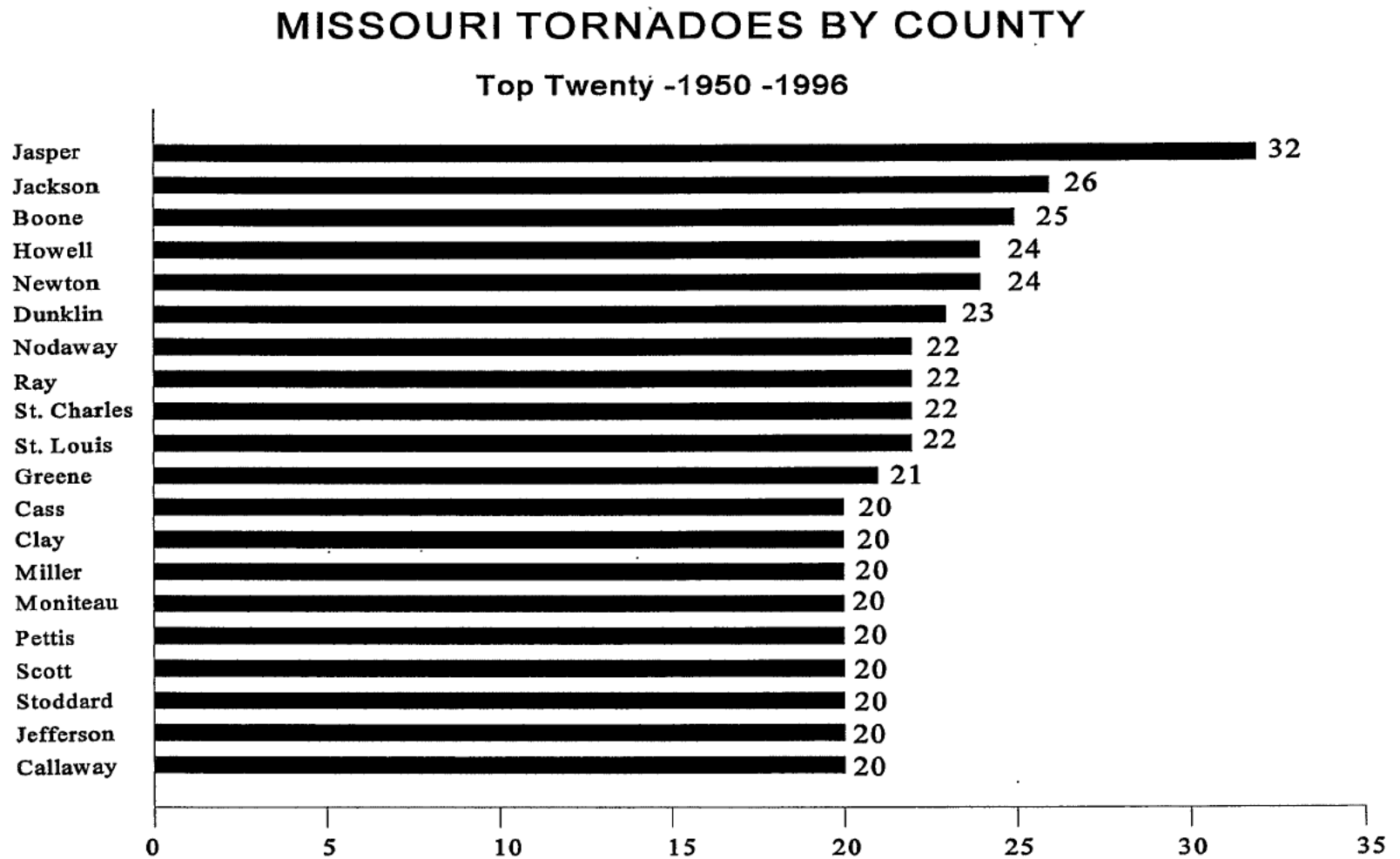


Figure 6

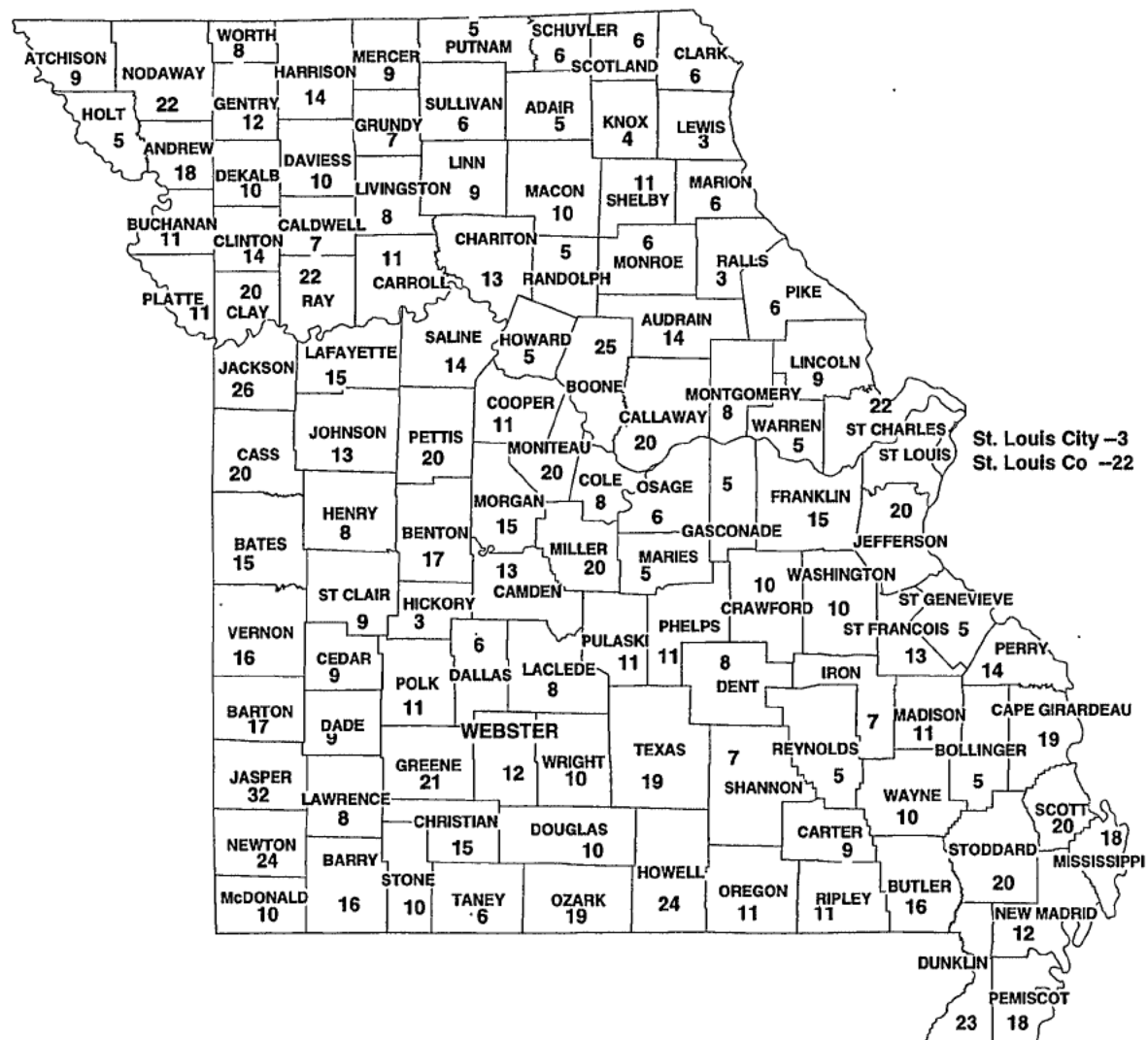


Figure 7

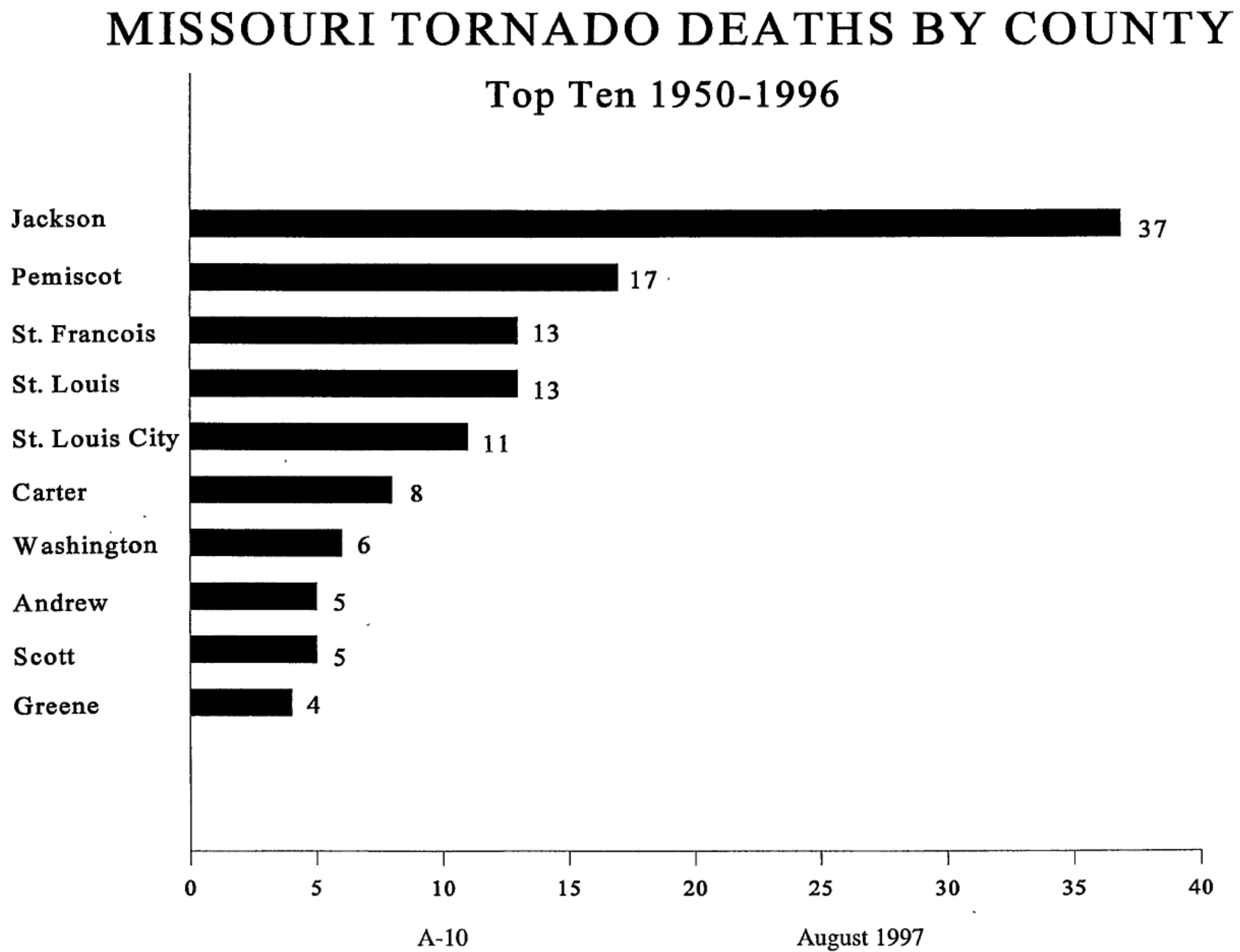


Figure 8

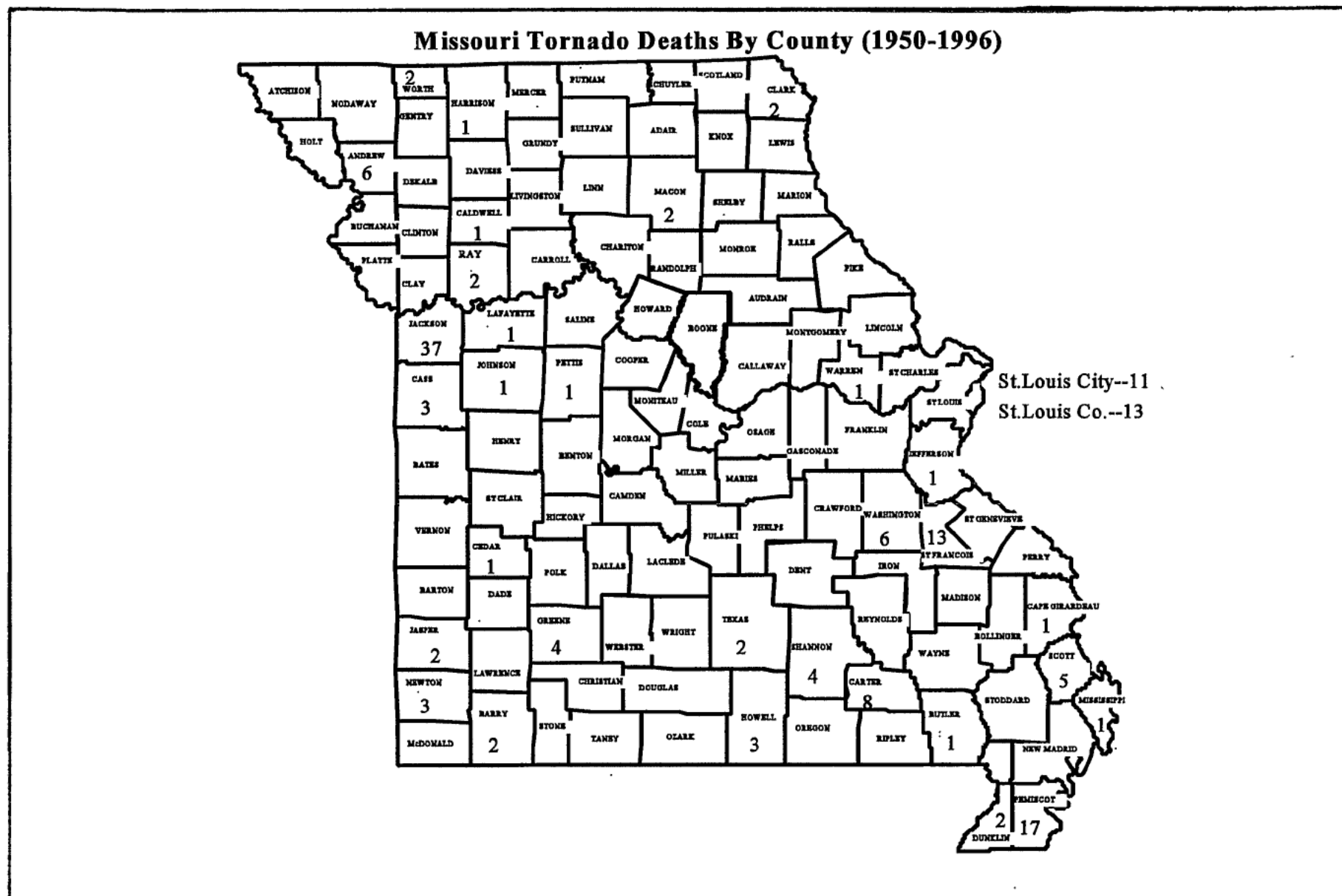


Table 4

MISSOURI TORNADO STATISTICS

1950 - 1996

Total Number of Tornadoes	1229
Total Number of Deaths	153
Total Number of Injuries	2287
Yearly Average of Tornadoes	26
Yearly Average of Deaths	3
Yearly Average of Injuries	48
Tornado Deaths 1916 - 1996	615

FLOODS

(MAJOR AND FLASH)

I. TYPE OF HAZARD

Floods (Major and Flash)

II. DESCRIPTION OF HAZARD

Floods are the number one weather-related killer in the United States. Between 1972 and 1991, an average of 146 fatalities per year were recorded for floods. A flood is partial or complete inundation of normally dry land areas. It is caused by the overflow of rivers and streams, and/or the unusual and rapid accumulation or runoff of surface waters from any source. There are several types of floods--flash, headwater, backwater, interior drainage are examples--with most flood deaths due to flash floods.

The areas adjacent to rivers and stream banks that serve to carry excess flood water during rapid runoff are called floodplains. A floodplain is defined as the lowland and relatively flat areas adjoining rivers and streams. The term base flood, or 100 year flood is the area in the floodplain that is subject to a one percent or greater chance of flooding in any given year, based upon historical records. Floodplains are a vital part of a larger entity called a basin--defined as all the land drained by a river and its branches.

The land that forms the State of Missouri is contained within either the Mississippi, Missouri, Arkansas, or White River Basins. The Mississippi River Basin drains the eastern part of the state; the Missouri River Basin drains most of the northern and central part of the state; the White River Basin drains the south central part of the state; while, the Arkansas River Basin drains the southwest part of the state. The Missouri River Basin drains over half the state as the river moves west to east across the state. When the Missouri River joins the Mississippi at St. Louis, it becomes part of the Mississippi River Basin--the largest basin in terms of volume of water drained on the North American continent.

The fact that most of the land that comprises the State of Missouri is part of the Mississippi-Missouri River drainage basin means that a significant portion of the land area of the state lies in floodplains. St. Charles County, for example, has 43% of the land that comprises the county in floodplains. In terms of agricultural land in Missouri, 34% of Missouri's cropland lies in a floodplain. This leaves a significant portion of the Missouri population and economic resources extremely vulnerable to flooding and, in fact, Missouri has been the scene of some of the most destructive flooding in the nation.

III. HISTORICAL STATISTICS

Missouri has a long and active history in terms of extensive flooding over the past century. Scores of river communities, such as those along the Mississippi and Missouri rivers, have become quite skilled and experienced in their flood fighting efforts due to rather frequent instances of severe flooding in recent years. Floods are generally characterized as slow moving disasters, allowing communities downstream sufficient time to take protective measures, such as sandbagging and evacuations. While these emergency response activities showcase community spirit with neighbors helping neighbors in protecting lives and property, the toll from these many disasters has been both devastating and widespread.

Ranking among the state's most notable flood disasters are the Missouri River flood of 1927, which spread destruction across 17 million acres, and the Flood of 1951, which caused an estimated \$400 million dollars in damage. Record flooding also occurred in 1973 along the Mississippi River, where backwater inundated 474,000 acres at a loss of \$40 million. The unseasonably heavy rainfall produced severe headwater flooding along many of the areas tributary streams, particularly in the St. John's Basin in Missouri and along the St. Francis and White Rivers in Arkansas. Of special historic interest is the December 1982 flood which spread dioxin-contaminated soil in the Times Beach area near St. Louis and led to a federal buyout of the entire town. In the fall of 1986, record flooding returned again in Missouri, as well as in Michigan, Illinois, Kansas and Oklahoma, with all these states declared as federal disaster areas. Significant flooding returned to the state in the spring of 1990, particularly along the Missouri River in western, central and portions of eastern Missouri.

FLOODS OF '93-95

The Floods of 1993-1995 represent Missouri's worst repetitive flood events. Within this time frame, there were five Presidential Disaster Declarations, including four in just one 12-month period. This extends from May 6, 1993 when the first declaration was issued by President Clinton, to April 17, 1994, when the fourth declaration was approved. Flooding in the Spring of '95 resulted in a fifth disaster declaration, issued on June 2, 1995. The ravages of the '93-'95 floods left a legacy of destruction, human suffering and property damage of unprecedented terms in Missouri history. The fact that Missouri will be recovering from the ravages of these repetitive flood disasters for several years is undisputed. In 1993 alone, a total of 112 of Missouri's 114 counties were included in at least one or more of the declarations. Only Cedar County in southwest Missouri and Dunklin County in the southeast portion of the state were not included in the declarations.

NOTE: Counties designated as Disaster Areas in the '93-'95 Floods are identified, by Disaster Declaration, in maps shown in Section VII of this annex.

SPRING '93 FLOODS

The origins of the Great Flood of '93 began with an extended period of wet weather starting 9-10 months prior to the onset of major flooding. Soils throughout the upper midwest became saturated by excessive rain in July, September, and especially November of 1992. This set the stage for rapid runoff and record flooding following another period of excessive rain in January through July of 1993. Precipitation in Missouri during that time was 150 to 200 percent above normal. Additionally, Kansas, Nebraska, and Iowa experienced significant rainfall during this same period.

Heavy spring rains which soaked the grounds in eastern Missouri during April and May 1993 caused extensive flooding in St. Charles and Lincoln counties. Six other eastern Missouri counties along the Mississippi River (Marion, Pike, Ste. Genevieve, St. Louis, Ralls, and Jefferson) were also adversely affected. These eight counties were included in the state's first Presidential Declaration for Individual Assistance as a result of 1993 spring flooding.

SUMMER '93 FLOOD

The rains continued into July and by mid-summer, prolonged rains produced catastrophic flooding along both the Mississippi and Missouri rivers, and their tributaries. A total of 102 counties and 3 cities were federally declared disaster areas for either Individual Assistance and/or Public Assistance. More than 30,000 Missourians evacuated their homes during the summer flooding and 21 deaths were attributed to that flood event. With these evacuations, it was estimated that more than 15,000 - 17,000 Missourians were unable to return to their homes for some time due to the flood damage. During the course of the summer flooding, 22 major river bridge closings, 250 routes, and 950 individual flood sites caused road closures in 112 counties. More than 280 million sandbags were used during the summer flooding alone.

The '93 summer flood represents the first time in which the Federal Response Plan was ever activated for a disaster in Missouri. There were 35 Disaster Application Centers opened across the state, including two mobile DACs to serve rural populations.

The average rainfall in the month of July was 9.48 inches. Northwest Missouri counties reporting more than 20 inches of rain in July included Holt, Nodaway, Andrew, Buchanan, Worth, Gentry, Mercer, Grundy, Sullivan, and Putnam. The 29 inches of rain that fell in Worth County during July were seven times the long term average and 18 inches greater than the previous record in 1958. (See table in Section VII for record water stages.)

FALL '93 FLASH FLOODS

Severe storms from November 13-19 combined with saturated soils to trigger flash flooding in much of the southeast and eastern areas of the state, and a portion of central Missouri. This resulted in a third Presidential Disaster Declaration for flooding in '93. There were 10 Missouri counties declared eligible for Individual Assistance, and 14 counties were declared for Individual Assistance and Public Assistance. During the November flooding, more than 12,000 people were evacuated and an additional 20 people died.

SPRING '94 FLOODS

Missouri's saturated soil conditions were likened to "a loaded gun with a hair trigger" as spring weather arrived in 1994. Severe weather, rains and early spring flash flooding, compounded by the water logged soil, caused 30 rivers and creeks in every Missouri county to rise between April 9-14. Evacuations were ordered in Lincoln, Reynolds, Jefferson and St. Charles counties. Another 11 Missourians lost their lives as a result of the flood event, which led to the state's fourth Presidential Disaster Declaration in a 12-month period. Ultimately, 17 counties and the City of St. Louis were included in that declaration for Individual Assistance.

SPRING '95 FLOOD

The Flood of '95 was the second largest flood of record in many areas of Missouri and the third largest flood in others. Severe weather and flooding conditions were widespread over the State throughout much of May. As Missouri River levels rose in the western part of the State, communities downstream began preparations for flooding in their areas. The combination of the Illinois, Ohio and Missouri River flooding caused the Mississippi to flood as well. By May 17, more than 45 Missouri counties suffered from road closures and flood conditions. A 12" rain caused sheet flooding in St. Louis, and citizens in Hazelwood and Maryland Heights were evacuated. On June 2, 1995, President Clinton issued a Disaster Declaration for Public Assistance, which initially included 12 counties. The declaration was later amended on June 12, 1995 to include Individual Assistance. Ultimately, 61 Missouri counties were included under MO-DR 1054, with 43 counties eligible for Public Assistance and Individual Assistance, and 18 counties and one city declared for Individual Assistance only. A total of five deaths were directly attributed to the flooding. Three additional people died from drowning while trying to swim across flooded waters. On July 7, 1995, the U.S. Department of Agriculture issued a disaster declaration for 107 Missouri counties, triggering crop loans for farmers hurt by the prolonged rains and flooding.

Although the '95 Flood was very severe in many places, there were some 2,000 fewer families living in the floodplain as a result of Missouri's hazard mitigation activities under the Community Buyout Program. Begun in the aftermath of the Summer '93 Flood, the voluntary program is designed to acquire residential properties in the floodplain and move residents out of harm's way, using a mix of federal funds. No one could predict Missouri would have the opportunity to test the Buyout's effectiveness as quickly as it did when the Spring '95 Flood struck. Removing these repetitive loss properties from the floodplain saved millions in disaster assistance and emergency protective measures statewide. Likewise, claims for flood insurance and applications for disaster assistance, such as with the Small Business Administration or the Individual and Family Grant Program, were minimized.

IV. MEASURE OF PROBABILITY AND SEVERITY

In terms of overall damage, Missouri's most severe single hazard is flooding. While the state averages some 25 tornadoes each year, damage is generally confined to small areas with few fatalities, if any. By contrast, flooding has resulted in more federal disaster declarations in Missouri than any other hazard in the past three decades. Prior to the Great Floods of '93, Missouri received federal disaster declarations due to flooding in the spring of 1990: October 1986; June 1984; December 1982; August 1982 (Jackson County); April 1979; September 1977; July 1976; June 1974; and for extensive flooding in April 1973 and again in November 1973. The only other hazard resulting in federal declarations was for tornadoes in 1975 at Neosho, in 1977 at Sedalia and Pleasant Hill, and in 1980 at Sedalia.

Missouri's vulnerability to flooding is greatly increased because it is subject to flooding from two principal sources: the Missouri River Basin and the upper Mississippi River Basin. Over one-third of the annual monetary losses due to flooding in the Missouri River Basin occurs within this state.

Flash flooding could occur virtually anywhere in the state where there is an abundance of rainfall in a very short time span - as witnessed with the November '93 flood disaster. The backing up of tributary stream flow creates flooding problems along the Mississippi River, especially in the southern area of the state where the land tends to be very flat and at low elevations. Even though many flood control projects have been implemented which directly aid the state in flood prevention, the state is still flood prone due to its geography and location.

The National Weather Service has three response levels for alerting the public as to the danger of floods:

RESPONSE LEVEL	ACTIVITY
Flood Watch	Flash flooding or flooding is possible within the designated area.
Flood Warning	Flash flooding or flooding has been reported or is imminent--take the necessary precautions at once.
Flood Advisory	Flooding of small streams, streets and low-lying areas, such as railroad underpasses and urban storm drains, is occurring.

The threat of flooding is a more natural occurrence in the spring, when late winter or spring rains, coupled with melting snow, fill river basins with too much water, too quickly. Spring also represents the onset of severe weather in the form of thunderstorms, tornadoes, and heavy rains which generate flash flooding along these storm fronts. However, as demonstrated by the disaster declarations in December 1982 and the Great Summer Flood of '93, severe flooding can occur in Missouri at any time of the year. **Based on this information the State rates the probability and severity of floods as high.**

V. IMPACT OF THE HAZARD

The Federal Emergency Management Agency estimates that more than 216,000 households are within designated floodplains in Missouri. In addition, thousands of other Missouri residents are at risk to the dangers of flash flooding from rapidly rising creeks and tributaries, storm water runoff, etc. Nationwide, most flood deaths are from flash floods, and nearly half of these type of fatalities are auto related, according to the National Weather Service.

Of the 49 deaths recorded during the Floods of '93, 35 fatalities (or 71 percent) were from flash floods. In that same category, 20 deaths (77 percent) were related to motor vehicles caught in flash floods. Missouri's river flooding in 1993 claimed 14 lives, with 6 deaths (23 percent) attributed to motor vehicles. (See flood-related mortality charts in Section VII.

Missouri flood disasters have inflicted tremendous loss in terms of damage to personal property, businesses, infrastructure/ public property, and agriculture. Total losses during the '93 flood disasters were estimated at approximately \$3 billion. In addition, agricultural losses were estimated at \$1.8 billion, as 3.1 million acres of farmland were either damaged or went unplanted because of the '93 rains. The Department of Agriculture estimated that 445,000 acres of Missouri River bottomland was destroyed by washouts and sand scouring. While levees designed to protect up to 50-year floods did their jobs, the amount of rain and up river flooding took their toll. Of the 1,456 public and private levees in the state, some 840 were damaged.

Almost every Missourian was at some time affected by the floods through inundation of roadways, airports, drinking water and sewage treatment facilities, and by loss of income. The Missouri Department of Labor and Industrial Relations reported that \$6.2 million was disbursed for disaster unemployment assistance for people who lost work due to flooding from July 1993 through March 1994.

The floods of 1993-94 pointed out the painful fact that too many Missourians were living in the floodplain. To rebuild in the floodplain, those whose homes sustained substantial damage (50 percent or more) were required to elevate the structure above the base flood level to protect from future flood damage. Under Missouri's Community Buyout Program, more than \$30 million in federal dollars was committed to moving Missourians voluntarily out of the floodplain through the acquisition of primary residential property. It is estimated that state taxpayers will save more than \$200 million in future flood disaster claims.

VI. SYNOPSIS

Flood events are often accompanied by other types of severe weather, including tornadoes, lightning, and severe thunderstorm activity. These storms also present a danger to life and property, often resulting in many injuries, and in some cases, fatalities as well.

Flood waters themselves often interact with the presence of hazardous materials. This has prompted the evacuation of many citizens near such materials stored in large containers which may break loose or puncture as a result of flood activity. Such events occurred during the '93 Flood when some 11,000 St. Louis residents residing near flood-threatened propane tanks were evacuated on July 30th. Evacuations were also ordered on July 31 when bulk propane tanks were flooded by the River Des Peres in St. Louis County. Federal and state agencies retrieved more than 247 large storage tanks, 1,178 small tanks, 3,470 large drums (over 15-gallon), and 5,731 small drums which had been swept away by the floods.

Public health concerns which develop as a result of flooding include the need for disease and injury surveillance, community sanitation to evaluate flood affected food supplies, private water and sewage sanitation, and vector control (for mosquitoes and other entomology concerns.)

VII. MAPS OR OTHER ATTACHMENTS

River Basin and Floodplain Maps are on file at the State Emergency Management Agency.

Table 1

**RECORD HIGH WATER STAGES IN MISSOURI
DURING THE SUMMER 1993 FLOOD (IN FEET)**

River	1993 Level	Previous Record	Flood Stage
Mississippi River			
Hannibal	31.8	28.6	16
St. Louis	49.4	43.3	30
Cape Girardeau	48.0	45.6	32
Missouri River			
St. Joseph	32.7	26.8	17
Kansas City	48.9	46.2	32
Jefferson City	38.6	34.2	23
Hermann	36.3	35.8	21
St. Charles	39.5	37.5	

Source: U.S. Army Corps of Engineers (1993)

Table 2

DISTRIBUTION OF LEVEE FAILURES BY CORPS OF ENGINEERS DISTRICT

NUMBER OF FAILED OR OVERTOPPED LEVEES, SUMMER '93 FLOOD

COE DISTRICT	FEDERAL LEVEES	NON-FEDERAL LEVEES
St. Louis*	12 of 42	39 of 47
Kansas City**	6 of 48	810 of 810

* includes eastern Missouri and portions of Illinois

** includes northwestern, west central and portions of southwest Missouri, and areas in Kansas and Nebraska.

Note: The difference in the failure rate in the table above is due to the fact that most Federal levees are designed to withstand a 100-500 year flood, while non-federal levees, predominately protecting agricultural lands, are frequently designed for a flood with a return period of 50 years or less. **Source:** Natural Disaster Survey Report, "The Great Flood of '93."

Figure 1

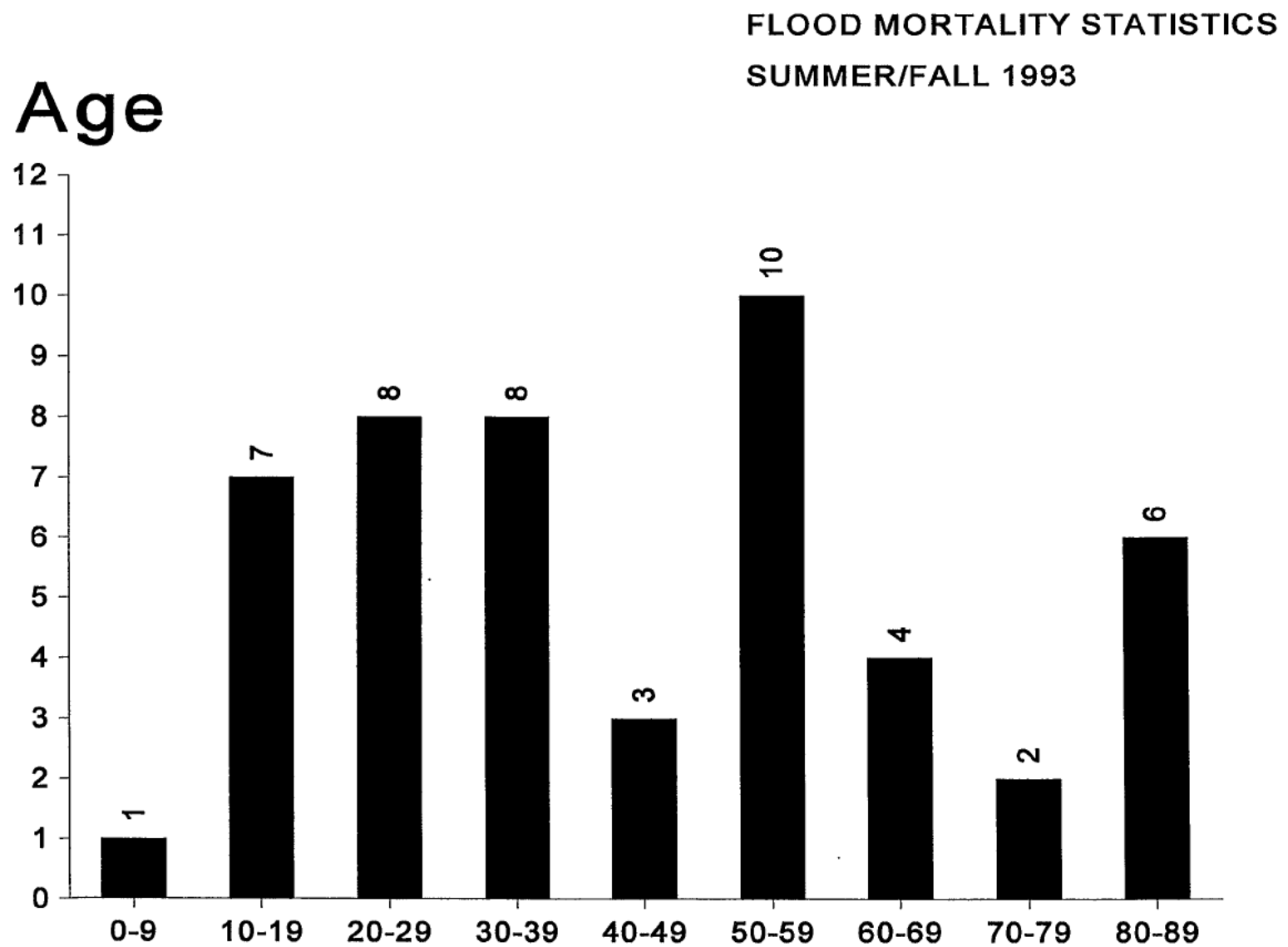


Figure 2

FLOOD MORTALITY STATISTICS SUMMER/FALL 1993

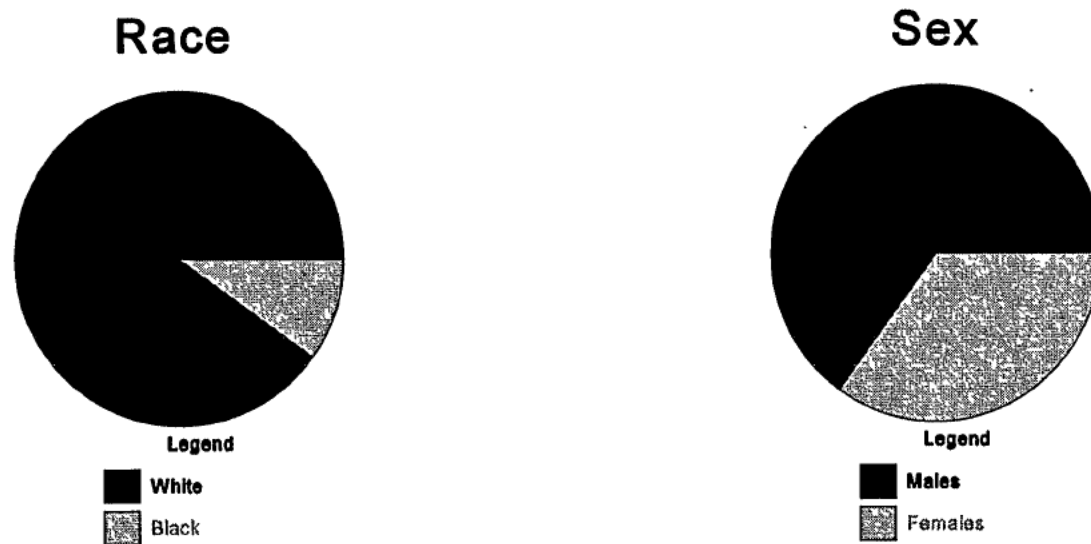


Figure 3

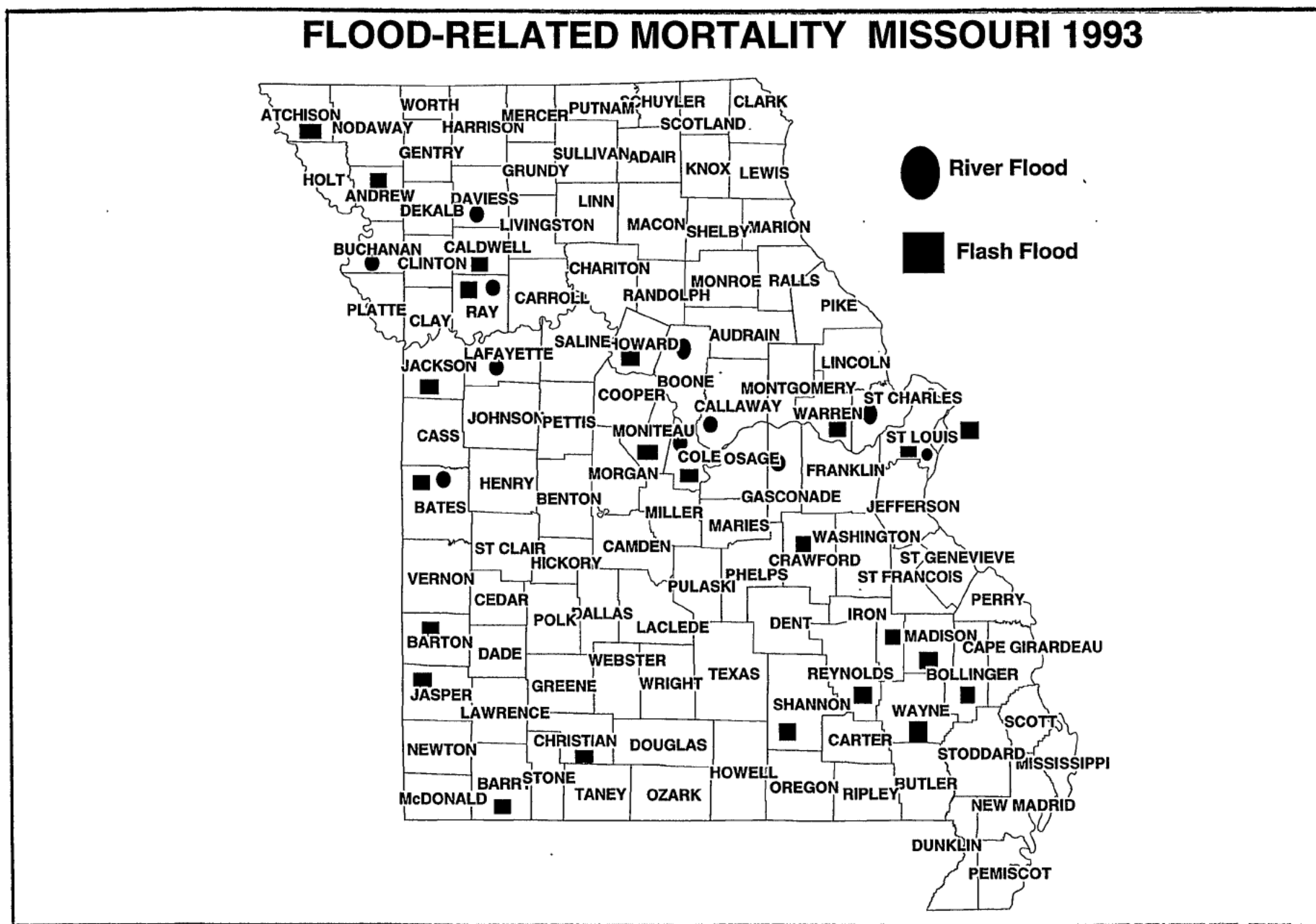


Table 2

**SUMMER/FALL 1993
CAUSES OF DEATH BY TYPE OF FLOOD**

	River Flood	Flash Flood	Total
Motor Vehicle	6 (23%)	20 (77%)	26 (53%)
Drowning	5 (25%)	14 (74%)	19 (39%)
Electrocution	1 (50%)	1 (50%)	2 (4%)
Cardiac	2 (100%)	0	2 (4%)
All Causes	14 (29%)	35 (71%)	49 (100%)

Figure 4

SPRING 1993 FLOOD

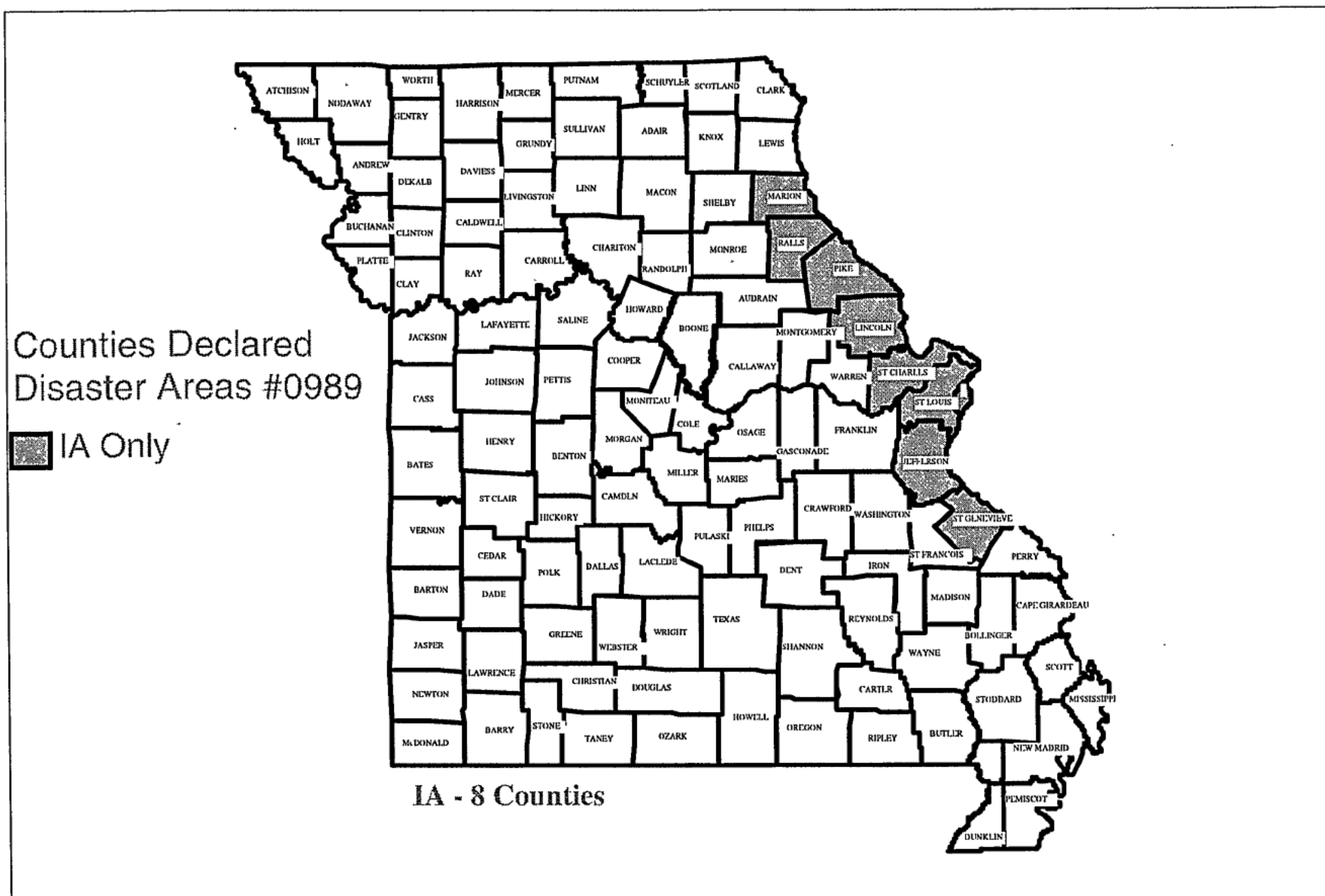
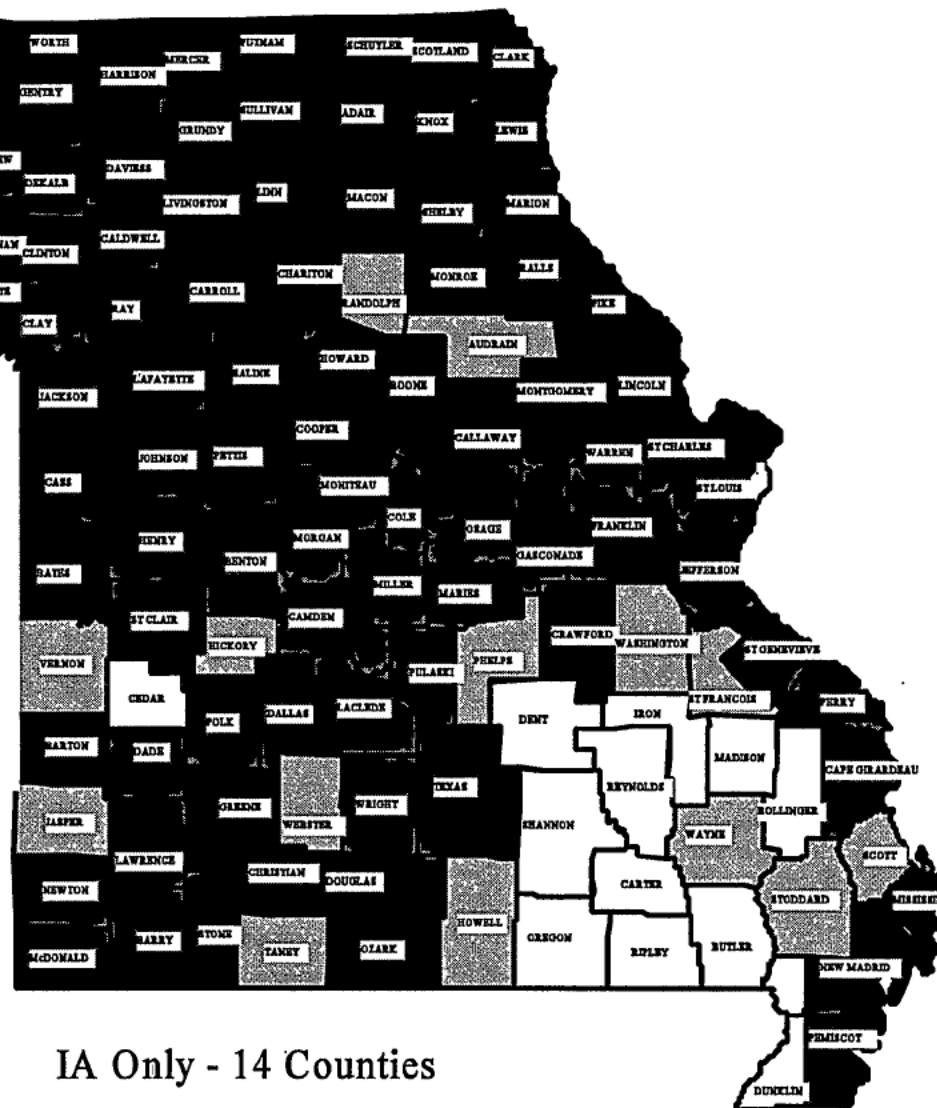


Figure 5

SUMMER 1993 FLOOD

Counties Declared Disaster Areas #995

-  IA Only
-  IA and PA



IA Only - 14 Counties

IA and PA - 88 Counties, 3 Cities

FALL 1993 FLOOD

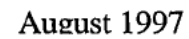


Figure 7

SPRING 1994 FLOOD

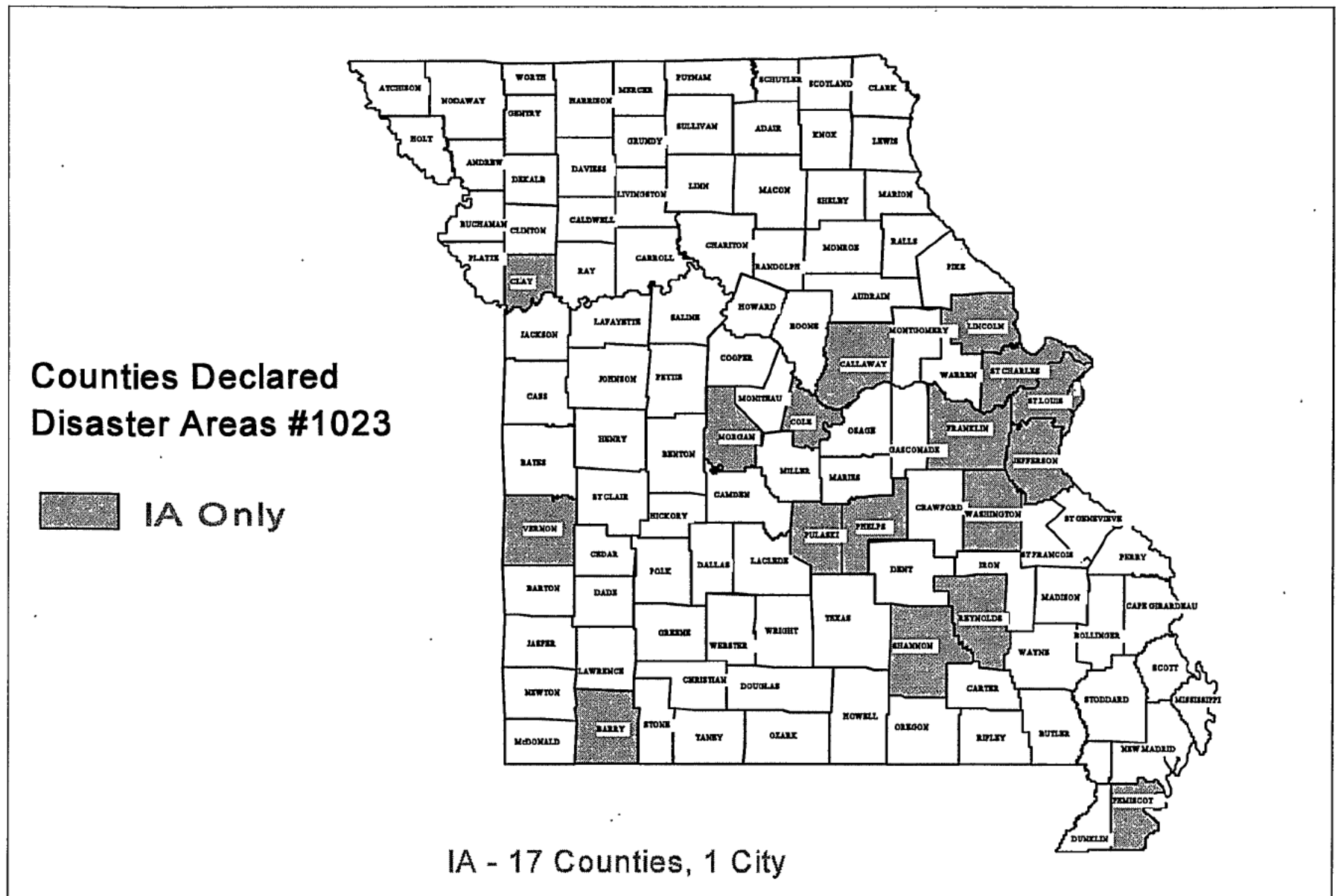
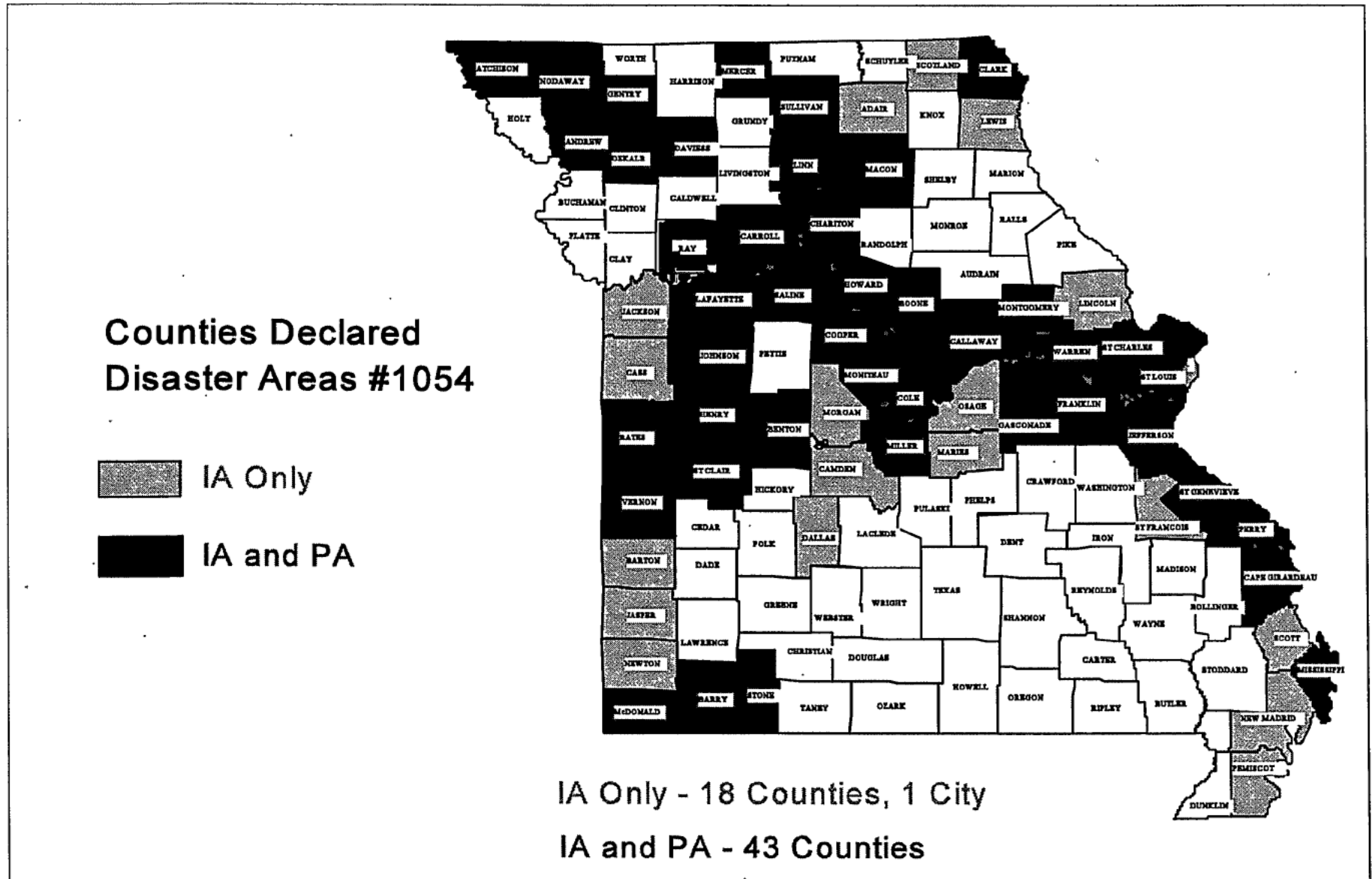


Figure 8

SPRING 1995 FLOOD



**SEVERE WINTER WEATHER
(SNOW, ICE, EXTREME COLD)**

I. TYPE OF HAZARD

Severe Winter Weather (Snow/Ice Storms, Extreme Cold)

II. DESCRIPTION OF HAZARD

Severe winter weather, including snow storms, ice storms and extreme cold, can affect any area of Missouri. The greatest threat is likely to occur in the area north of the Missouri River. Severe weather, such as snow, ice storms and extreme cold can cause injuries, deaths and property damage in a variety of ways. Winter storms are considered deceptive killers. This is because most deaths are indirectly related to the storm. Causes of death range from traffic accidents due to adverse driving conditions such as icy roads, to heart attacks caused by overexertion while shoveling snow and other related activities. Hypothermia or frostbite may be considered the most direct causes of death and injuries which can be attributed to winter storms and or severe cold. Economic cost are also difficult to measure. Heavy accumulations of ice can bring down trees, electric power lines and poles, telephone lines and communications towers. Crops, trees and livestock can be killed or injured due to deep snow, ice or severe cold. Buildings and automobiles may be damaged from falling tree limbs, powerlines and poles. During a state of emergency declaration in December 1994, approximately 26,000 customers in northern Missouri were without electric power due to an ice storm which broke tree limbs and downed power lines. Outages ranged from several hours to seven or eight days. Local governments, home and business owners and power companies were forced to spend millions of dollars for restoration of services, debris removal and landfill hauling.

Types of the different watches and warnings during severe winter weather are listed below:

Winter Storm Watch	Severe winter conditions, such as heavy snow and/or ice are possible within the next day or two.
Winter Storm Warning	Severe winter conditions have begun or are about to begin.
Blizzard Warning	Snow and strong winds will combine to produce a blinding snow (near zero visibility), deep drifts and life-threatening wind chill.
Winter Weather Advisory	Winter weather conditions are expected to cause significant inconveniences and may be hazardous. If caution is exercised, these situations should not become life-threatening. The greatest hazard too often is to motorists.
Frost/Freeze Warning	Below freezing temperatures are expected and may cause significant damage to plants, crops or fruit trees. In areas unaccustomed to freezing temperatures, people who have homes without heat need to take added precautions.

III. HISTORICAL STATISTICS

Weather data indicates that the Missouri counties north of the Missouri River may receive an average annual snowfall of 18 to 22 inches. Counties south of the Missouri River may receive an annual average of 8 to 12 inches. The events in which borderline conditions exist between freezing rain and icing conditions instead of rain or snow are highly unpredictable. The duration of the more serious events combined with other factors such as high winds are also highly unpredictable. The degree of severity may be localized to a small area due to a combination of climatic conditions. Statistical information regarding hypothermia mortality is included in the "Hypothermia Mortality in Missouri 1984-94" data provided by the Missouri Department of Health at the end of this report.

IV. MEASURE OF PROBABILITY AND SEVERITY

It is quite difficult to make an objective and quantitative measure of the probability and severity of snow storms, ice storms and extreme cold. Therefore, an analysis should be considered subjective and qualitative.

For areas north of the Missouri River, the probability of a snow storm, ice storm or extreme cold should be considered high, due to the history of higher average snowfall and lower average temperatures. However, the severity is rated moderate due to the overall level of preparedness due to the history of this area. People are "just used to it". For example, homes and businesses may be better insulated due to the higher probability of severe cold relative to other areas. People living in this area may be more likely to utilize snow tires or purchase four-wheel drive vehicles. People living in this area may be more likely to maintain adequate supplies of home heating fuels and consider other preparedness measures. Local and state governments may have access to more snow clearing equipment and maintain adequate supplies of materials needed for snow or ice removal. School districts and businesses may be more likely to develop and utilize snow routes or establish closing procedures.

Areas south of the Missouri River may have a low probability of a snow storm, ice storm or extreme cold. These areas may have a moderate severity to these events. This may be due to complacency and a lower level of preparedness. People living in this area may have homes with inadequate insulation or fail to maintain an adequate supply of home heating fuels. People may be less likely to equip their vehicles with snow tires or purchase four-wheel drive vehicles. Local and state governments may not maintain sufficient amounts of equipment and materials. Schools and businesses may not establish formal snow routes or closing procedures.

V. IMPACT OF THE HAZARD

People are affected by the adverse effects of winter storms, ice storms and extreme cold; some more than others. Those over 65 years of age are especially vulnerable, as indicated by the Missouri Department of Health data, (141 hypothermia related deaths from 1984 to 1994) 51 percent occurred to those persons over age 65. General observations by the National Oceanic and Atmospheric Administration (NOAA), indicated that in winter deaths related to exposure to cold: 50% were over 60

years old, over 75% were male and about 20% occur in the home. Of winter deaths related to ice and snow: about 70% occur in automobiles, 25% of the people were caught out in the storm and the majority were males over 40 years old. As noted earlier, ice storms can cause significant economic costs to home owners, business owners and utility companies. The ice storm in December 1994 has shown what environmental damage can occur. Thousands of trees and plants were cut down or damaged as a result of the ice storm. The problems of debris clearance causes environmental damage due to the permitted burning of the debris or reduced landfill space.

VI. SYNOPSIS

As noted in this report, snow storms, ice storms and extreme cold can interact to cause many hazards. A difference of only a few degrees may be the difference between rain, ice or snow. Duration and intensity of any of these events will determine the overall impact of a particular event. Wind speed may be the difference between a minor snow or a blizzard. These events cannot be prevented. Preparedness for these events may be the greatest single factor to reducing loss of life, injury and property damage. NOAA weather information broadcasts via radio and television provide important information for people to prepare and reduce risks to their lives and property.

VII. MAPS OR OTHER ATTACHMENTS

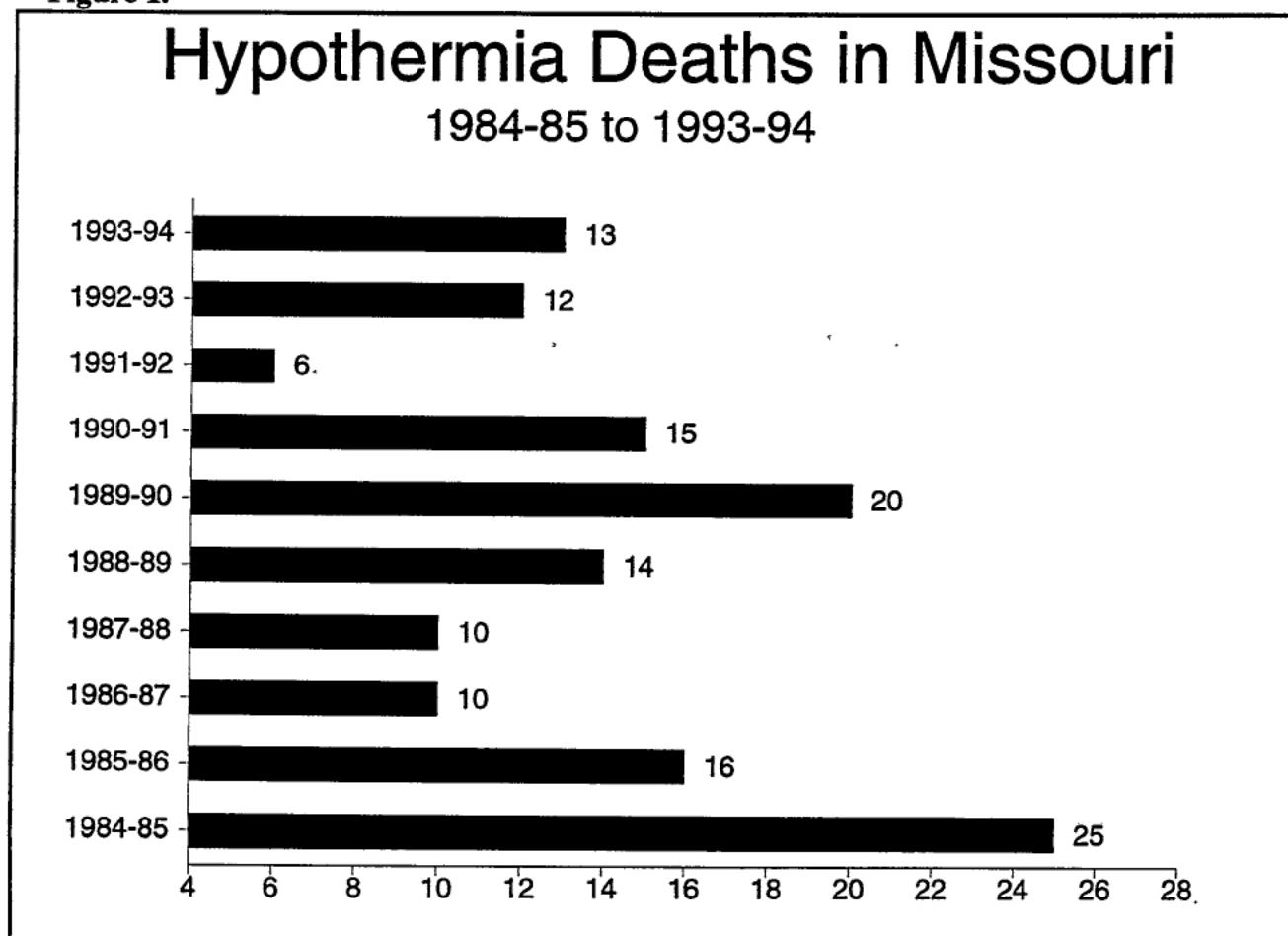
Hypothermia became reportable by law in Missouri effective April 8, 1993. Hypothermia is defined as a physician-diagnosed case of cold injury associated with a fall of body temperature to less than 94.1°F and resulting from unintentional exposure to a cold environment.

From 1984 - 1994, 141 Missourians have died of conditions related to excessive cold. The most severe winters were 1984-85 when 25 deaths occurred and 1989-1990 (see Figure 1). Of the total 141 deaths, 51 percent occurred in persons of age 65. The rate of mortality increased sharply at older ages. This emphasizes the need to be very supportive of persons at highest risk and especially so with increasing age.

Table 1. Hypothermia Deaths and Rates per 100,000 Population by Age Group, Missouri 1984-85 to 1993-94.

<u>Age Group</u>	<u>Frequency</u>	<u>Rate</u>
0-4	1	.26
5-14	1	.13
15-24	4	.55
25-34	12	1.40
35-44	13	1.77
45-54	15	2.87
55-64	22	4.81
65-74	22	5.59
75-84	28	11.56
85+	22	27.50
Unknown	1	

Figure 1.



DROUGHT

I. TYPE OF HAZARD

Drought

II. DESCRIPTION OF HAZARD

The dictionary definition of drought is a period of prolonged dryness. Current drought literature commonly distinguishes between three "categories" of drought, all of which define drought in simplified terms:

1. **Agricultural Drought**, defined by soil moisture deficiencies.
2. **Hydrological Drought**, defined by declining surface and groundwater supplies, and
3. **Meteorological Drought**, defined by precipitation deficiencies.

Each of these definitions relates the occurrence of drought to water shortfall in some component of the hydrological cycle. Each affects patterns of water and land use, and each refers to a repetitive climatic condition. In urban areas, drought can affect those communities dependent on reservoirs for their water, as decreased water levels due to insufficient rain can lead to the restriction of water use. In agricultural areas, drought during the planting and growing season can have a significant impact on yield.

To take the definition of drought even further, the U.S. Government definition of an agricultural drought incorporates specific parameters based upon historical records. Agricultural drought is "a combination of temperature and precipitation over a period of several months leading to a substantial reduction in yield (bushels per acre) of one or more of the three major food grains (wheat, soybean, corn). A substantial reduction is defined as a yield (bushels per acre) less than 90% of the yield expected with temperature/precipitation equal to long term average values."

Regardless of the specific definition, droughts are difficult to predict or forecast both as to when they will occur, and how long they will last. According to Dr. Grant Darkow, Department of Atmospheric Science, University of Missouri-Columbia, there is a recognizable "upper air flow pattern and simultaneous surface pattern associated with abnormal dryness over Missouri." When the upper air flow pattern is typified by air flowing in a broad arc over the central plains with higher speeds in southern Canada than over the U.S., then the air over the southern plains will be "characterized by a weak clockwise circulation." "Storm systems coming off the Pacific Ocean" will cross the extreme northwestern states and southern Canada, thus bypassing the midwestern states. When this flow pattern persists, the result can be a prolonged period of drought.

The most commonly used indicator of drought and drought severity is the Palmer Drought Severity Index (PDSI), which is published jointly by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture (USDA). The PDSI measures the departure of water supply (in terms of precipitation and stored soil moisture) from demand (the amount

of water required to recharge soil and keep rivers, lakes and reservoirs at normal levels). The result is a scale from +4 to -4, at 1.0 and .5 intervals. By relating the PDSI number to a regional index, one can compile data which reflects long-term wet or dry tendencies.

Above 4.0	Extreme Moist Spell
3.0 to 3.9	Very Moist Spell
2.0 to 2.9	Unusually Moist Spell
1.0 to 1.9	Moist Spell
0.5 to 0.9	Incipient Moist Spell
0.4 to -0.4	Near Normal Conditions
-0.5 to -0.9	Incipient Drought
-1.0 to -1.9	Mild Drought
-2.0 to -2.9	Moderate Drought
-3.0 to -3.9	Severe Drought
Below -4.0	Extreme Drought

Missouri is divided into six regions of similar climatic conditions for reporting purposes of the PDSI: Northwest, Northeast, West Central, Southwest, Southeast, and Bootheel. These regions are illustrated on the map (Palmer Drought Severity Index, Missouri Subregions), in Section VII of this annex.

In addition to the NOAA/USDA indices, water management agencies in Missouri have access to the Missouri Crop and Weather Report, produced by the Missouri Agricultural Statistics Service. These reports provide detailed statistical information on weather conditions, crop conditions, topsoil moisture supply and subsoil moisture supply by subregion throughout Missouri.

Other less conceptual indicators of drought include: measuring water demand versus supplies available, reductions in streamflow, declining reservoir levels, precipitation deficits, falling water levels in wells, and soil moisture supply.

The difficulty with recognizing or predicting drought is that no single indicator can be reliably used to predict onset. Regional indicators such as the Palmer Index are limited in that they respond slowly to deteriorating conditions, whereas observing surface conditions and groundwater measurements, or rainfall, may only provide a "snapshot" of a very small area.

Consequently, the use of a variety of drought indicators is essential for effective assessment of drought conditions, with the Palmer Index being the primary means to assess drought severity.

III. HISTORICAL STATISTICS

Missouri's average annual rainfall ranges from about 34 inches in the northwest to about 48 inches in the southeast. Even the driest areas of Missouri have enviable rainfall, compared to most western states. But lack of rainfall impacts certain parts of the state more than others because of alternate sources and usage patterns.

SOUTHERN MISSOURI - Most of the southern portions of Missouri are less susceptible to problems caused by prolonged periods of non rain, since there is abundant groundwater resources. Even with decreased streamflow or lowered reservoir levels, groundwater is still a viable resource in southern Missouri. Row-crop farming is not extensive and therefore agricultural needs aren't as great as in other parts of the state. The only exception is in the southwestern and southeastern areas where irrigation is used.

NORTHERN AND WEST CENTRAL MISSOURI - Most of the northern and west central portions of Missouri is underlain by rocks which are not conducive to water-bearing formations. They yield only small amounts of water, even during periods of normal and above normal rainfall. Under drought conditions, adequate amounts of water cannot be pumped from the rock formations of northern Missouri to supply even domestic needs. Most streams in northern Missouri do not receive appreciable groundwater recharge. During periods of drought, these streams are generally reduced to a series of pools, or may become completely dry. Streams and water impoundments are the only localized sources of water during droughts, and even these limited resources are at risk when the drought is prolonged. Agriculture in west-central and northern Missouri is usually the first to feel the effects of drought. Although row-cropping is more extensive in this part of the state, irrigation is generally not feasible - except on the floodplains of major rivers.

IV. MEASURE OF PROBABILITY AND SEVERITY

Because of its geographical location and characteristic weather patterns, Missouri is vulnerable to drought conditions, as is the Western Great Plains area. Agricultural droughts are the most common of record, particularly those inflicting damage to corn crop yields. Throughout much of this century, these droughts have occurred with common regularity (on the average of once every five years), according to the Missouri Crop and Livestock Reporting Service.

Of historic significance is Missouri's most recent severe drought, known as the "Great Drought of 1988-89". During this prolonged drought, water supplies for several Missouri municipalities were severely taxed, and in some cases exhausted altogether.

Based on a collection of Midwest drought data and evaluation work by its staff, the Missouri Department of Natural Resources (Water Resources Program) has produced a Missouri Drought Response Plan (1995). The primary purpose of the Drought Response Plan is to address the need for coordinated advanced emergency planning for state and local government. The plan outlines proactive emergency and tactical measures designed to better prepare the State for drought. It also emphasizes the need for long-range strategic planning, which would address the bigger issue of drought impact avoidance. Preventing water shortages in public water systems is considered one of the major goals of drought mitigation, as noted in the plan.

In preparing this document, DNR divided the state into three regions which are prioritized according to drought susceptibility. The three regions are identified as having **SLIGHT**, **MODERATE**, and **SEVERE** susceptibility to drought conditions. They are illustrated on the map (Drought Susceptibility) in Section VII of this annex. A description of the drought susceptibility for the three regions are as follows:

REGION A has very little drought susceptibility. It is a region underlain by sands and gravel (alluvial deposits). Surface and groundwater resources are generally adequate for domestic, municipal, and agricultural needs.

REGION B has moderate drought susceptibility. Groundwater resources are adequate to meet domestic and municipal water needs, but due to required well depths, irrigation wells are very expensive. The topography generally is unsuitable for row-crop irrigation.

REGION C has severe drought vulnerability. Surface water sources usually become inadequate during extended drought. Groundwater resources are normally poor, and typically supply enough water only for domestic needs. Irrigation is generally not feasible. When irrigation is practical, groundwater withdrawal may affect other uses. Surface water sources are used to supplement irrigation supplied by groundwater sources.

The Missouri Drought Response Plan relies primarily upon the Palmer Index to indicate drought severity, and supports its findings directly with streamflow, reservoir-level and groundwater-level measurements. Areas which appear to be the most vulnerable to drought are the focus of future drought planning, management and mitigation activities. **Based on this information, the State rates the probability and severity of the drought hazard as moderate.**

V. IMPACT OF THE HAZARD

A severe drought in the Southern Plains states from the Fall of 1995 through the Summer of 1996 resulted in more than \$4.0 billion in costs and damages to agricultural regions. The States of Texas and Oklahoma were most severely affected. In the Summer of 1993, a combination of drought and heat wave across the Southeast U.S. was responsible for about \$1 billion in costs and damages. Among the most costly disasters, however, was the Great Drought of 1988-89, which caused an estimated \$39 billion in losses in the United States. As a comparison, the record floods of 1993 in the Midwest inflicted damage in the range of \$12 to \$16 billion. Although more subtle in terms of physical damage, the social and economic costs of drought are substantial.

Drought, as it affects the citizens of Missouri in terms of health and safety, is primarily a problem of rural water supply. With some exceptions, larger municipalities have not experienced major problems in the past that have impacted some of the smaller communities. Most seriously affected are those supplied by small water structures. In its scope, a drought may be limited to a localized problem, or even a regional problem. Based on severity and duration, it may even become a statewide problem, at least in terms of overall impact, such as the commitment and shifting of resources and other response issues. Good water quality and a plentiful supply are two factors in daily life which are often taken for granted. But when good water becomes a scarce commodity and people must compete for the available supply, the importance of these two factors increases dramatically. The State Water Resources Plan (RSMO 640.415), which is a provision of the Water Resources Law enacted by the Missouri Legislature in 1989, requires the Department of Natural Resources to ensure that the quality and quantity of Missouri's water resources are maintained at the highest possible level to support present and future beneficial uses. The provision was established to provide for the development, maintenance and

periodic updating of a long-range comprehensive statewide plan for the use of surface and groundwater. It includes existing and future requirements for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs.

VI. SYNOPSIS

In addition to damage to crops, produce, livestock, soil, and the resulting economic consequences, the arid conditions created by drought pose an increased risk to fire. The danger is especially high for brush fires, grass fires and those in wooded areas which can threaten homes and other structures in their path. Lack of water resources in rural areas can complicate the firefighting effort.

Severe drought also poses health threats to citizens due to water shortages and the extreme heat. Particularly vulnerable are children, the elderly and those with respiratory problems. Contaminated or poor water quality for drinking and sanitation measures also cause a variety of serious illnesses.

VII. MAPS OR OTHER ATTACHMENTS

Figure 1 - Palmer Drought Severity Index

Figure 2 - Drought Susceptibility

Figure 1

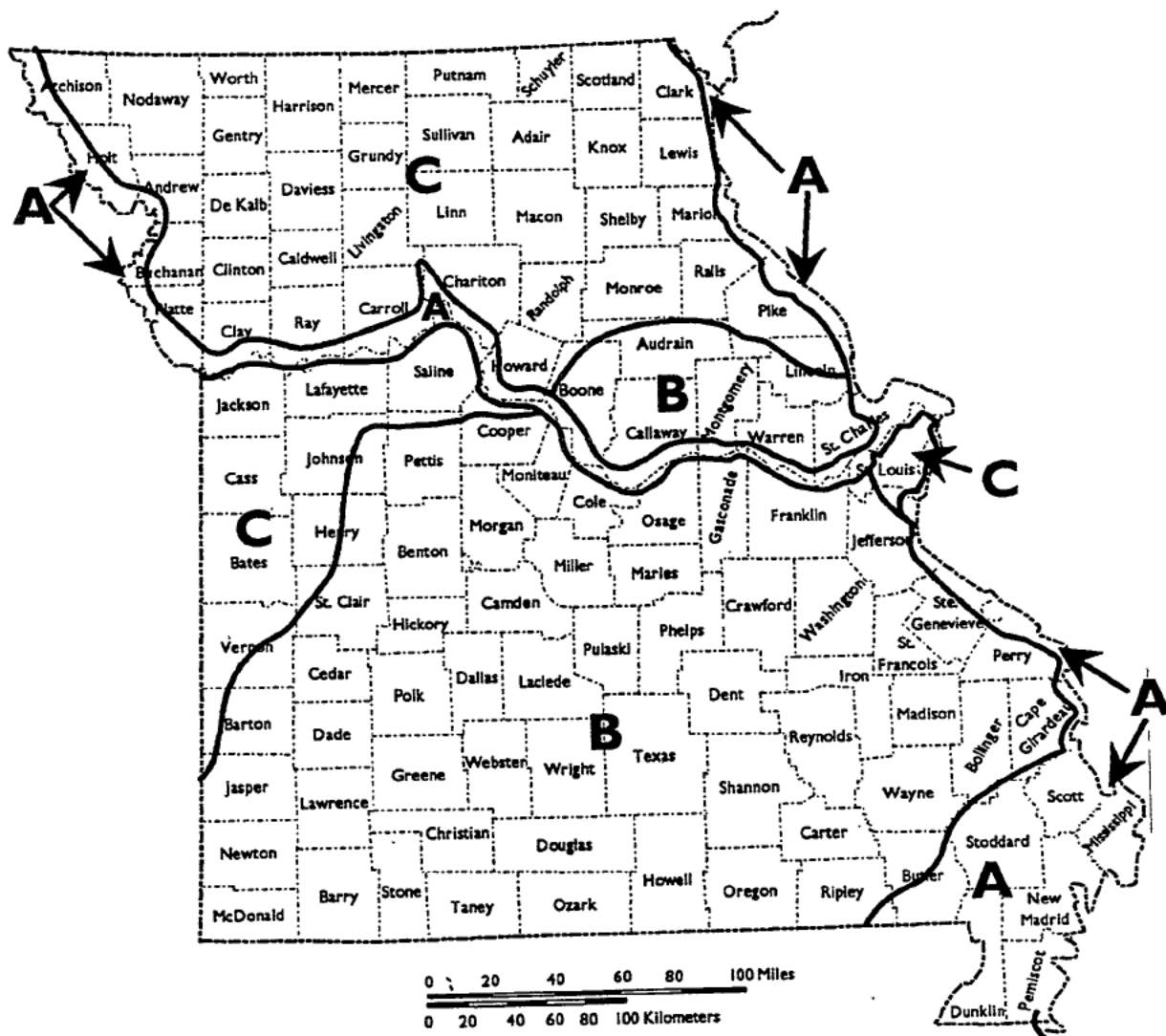
PALMER DROUGHT SEVERITY INDEX

MISSOURI SUBREGIONS



Figure 2

DROUGHT SUSCEPTIBILITY



Region A: Slight Susceptibility
 Region B: Moderate Susceptibility
 Region C: High Susceptibility

HEAT WAVE

I. TYPE OF HAZARD

Heat Wave

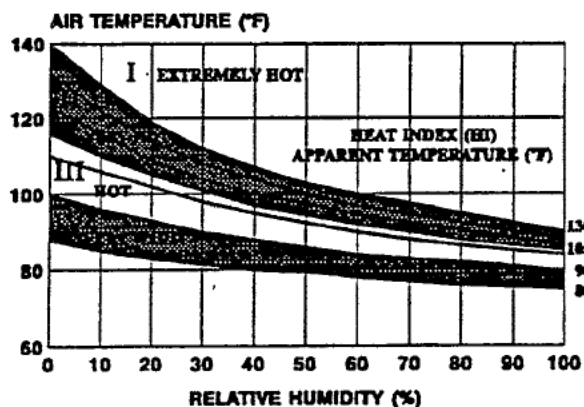
II. DESCRIPTION OF HAZARD

The National Weather Service defines a heat wave as three consecutive days of 90°F plus temperatures. These high temperatures generally occur from June through September, but are most prevalent in the months of July and August. Missouri experiences about 40 days per year above 90 degrees, based on a 30-year average compiled by the NWS from 1961-1990. July leads this statewide mean with 15 days above 90 degrees, followed by August with an average of 12 days over 90. June and September average 6 days and 4 days respectively for temperatures above 90 during the same 30-year period. This is based on local climatological data from NWS stations at Kansas City, Columbia, Springfield, and St. Louis. As these regional reports indicate, all of Missouri is subject to heat wave during the summer months.

Ambient temperature however, is not the only factor to consider when assessing the likely effect of heat. Relative humidity must also be considered, along with exposure, wind, and activity. The NWS has devised a Heat Index (HI) which is a combination of air temperature and relative humidity, and is more reflective of how hot it really feels.

Figure 1

HEAT INDEX



The shaded zone above 105°F corresponds to a level of Heat Index that may cause increasingly severe heat disorders with continued exposure and/or physical activity.

These Heat Index values were devised for shady, light wind conditions. Exposure to full sunshine can increase HI values by up to 15 degrees. Strong winds, particularly strong very hot, dry air can cause rapid evaporation of perspiration, and dangerously increase body temperature.

The military uses the wet-bulb globe temperature as a means for assessing heat stress on soldiers. The standard dry-bulb thermometer temperature is a poor predictor of heat illness risk, since it does not take into account humidity, wind velocity, or radiated heat. Tables correlating dry-bulb temperature and humidity are better, but still do not correct for convection or radiation. The most accurate measure of environmental heat stress is the Wet-Bulb Globe Thermometer index which measures three forms of heat load.

III. HISTORICAL STATISTICS

Over the past nine decades, the Missouri State Department of Health has compiled statistics for deaths from excess heat. Between 1911-1920 there was an average of 73 deaths per year; between 1921-1930 there was an average of 72 deaths per year; between 1931-1940 an average of 203; 1941-1950, 26; 1951-1960, 57; 1961-1970, 22; 1971-1980, 38; 1981-1990, 21. These fatality averages are illustrated in the bar graph in Section VII. The worst years were during the Great Depression with 843 deaths in 1934, and 644 in 1936. The worst year in recent memory was 1980 with 295 deaths from excess heat.

IV. MEASURE OF PROBABILITY AND SEVERITY

Based on 30-year statistics from the National Weather Service indicating the state's mean number of days above 90 degrees during the summer months, Missouri is vulnerable to heat waves ranging from **HIGH** to **MODERATE** risk in the July and August months. The N.W.S. has developed a Heat Index/Heat Disorder Chart that relates ranges of HI with specific disorders, particularly for people in higher risk groups.

Table 1

HEAT INDEX	HEAT DISORDER
130 F or higher	heat stroke/sunstroke likely with continued exposure
105 F to 129 F	sunstroke, heat cramps or heat exhaustion likely and heat stroke possible with prolonged exposure and/or physical activity
90 F to 104 F	sunstroke, heat cramps and heat exhaustion possible with prolonged exposure and/or physical activity
80 F to 89 F	fatigue possible with prolonged exposure and/or physical activity

The National Weather Service has designated three response levels based upon the Heat Index in order to alert the public to the potential heat hazard:

Table 2

HEAT INDEX	RESPONSE LEVEL
130 F or higher	Warning
105 F to 129 F	Watch
90 F to 104 F	Advisory

Based on information from the Department of Health and the National Weather Service, the State rates the probability as moderate and severity as moderate, but could be upgraded to severe.

V. IMPACT OF THE HAZARD

The severity of heat disorders tends to increase with age. Heat cramps in a 17-year-old can become heat exhaustion for someone in their forties, and may result in a fatal stroke for someone in their sixties. Population groups at risk to becoming very sick from heat waves are:

(1) Those Vulnerable To Heat Stress Due To Physical Condition

- (a) Older People
- (b) Children
- (c) People Overweight or Underweight

(2) People With Limited Independence Due To Physical, Mental Disorders

- (a) People in institutional settings without air conditioning
- (b) People working in heat under stress (firefighters, police, EMS)
- (c) People in urban environments, where heat retention in asphalt, concrete and masonry is a factor (heat island effect)
- (d) People with low income who lack resources for air conditioning, transportation, medical care, etc.

(3) Those With Increased Risk From Work, Leisure Activities

- (a) People who work outdoors (utility, construction crews, etc.)
- (b) Military personnel and trainees
- (c) Athletes

(4) Those More Difficult To Reach Through Normal Communications

- (a) People who live alone
- (b) People who are homeless
- (c) People who do not speak English
- (d) People who cannot read
- (e) People who are culturally, socially or geographically isolated

Even when a heat injury isn't fatal, it can be extremely serious and require lifelong monitoring of further exposure to heat. Besides mortality statistics due to heat, the Missouri Department of Health tracks heat-related injuries. A series of charts in Section VII show Missouri heat-related illnesses for '91-'94 Summers.

VI. SYNOPSIS

Heat waves are often a major contributing factor to power outages (brownouts, etc.) as the high temperatures result in a tremendous demand for electricity for cooling purposes. Power outages for prolonged periods increase the risk to heat stroke and subsequent fatalities due to loss of cooling and proper ventilation.

Other interrelated hazards include water shortages, brought on by drought-like conditions and high demand. Local advisories which list priorities for water use and rationing are common during heat waves. Civil disturbances and riots are more likely to occur during heat waves, as well as incidents of domestic violence and abuse, government authorities report.

VII. MAPS OR OTHER ATTACHMENTS

Attached are the Missouri Department of Health statistics.

Figure 2

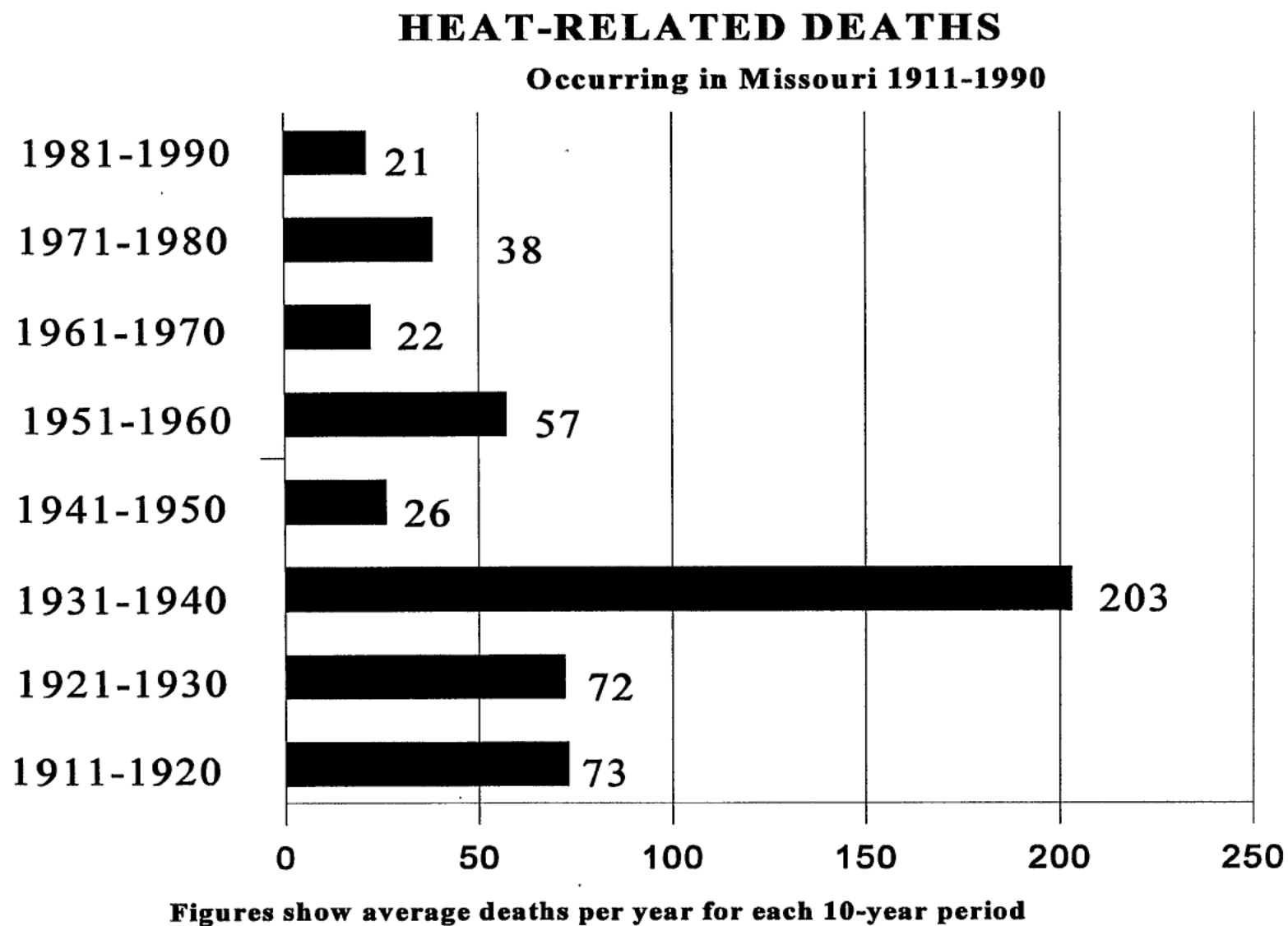


Table 3

MISSOURI HEAT-RELATED ILLNESS
Summer 1991

Week Ending	St. Louis	Northeast	Kansas City	Central	Southwest	Southeast	Weekly Total	Yearly Total
June 1	7	-	-	-	-	2	9	9
June 8	1	-	-	-	1	1	3	12
June 15	12	-	-	-	1	1	13	25
June 22	7	-	1	-	-	-	8	33
June 29	16	-	-	-	-	-	16	49
July 6	24	-	6	-	2	-	32	81
July 13	9	-	-	-	-	-	9	90
July 20	-	-	15				16	106
July 27	13	-	2	1	-	-	16	122
August 3	13	-	3	-	1	8	25	147
August 10	1	-	-	-	-	2	3	150
August 17	-	-	1	-	-	1	2	152
August 24	4	-	-	-	-	5	9	161
August 31	2	-	1	-	-	-	3	164
September 7	-	-	-	-	-	-	0	164
September 14	10	-	-	-	-	1	11	175
September 21	2	-	-	-	-	-	2	177

Source: Missouri Department of Health September 22, 1991

Table 4

MISSOURI HEAT-RELATED ILLNESS
Summer 1992

Week Ending	St. Louis	Northeast	Kansas City	Central	Southwest	Southeast	Weekly Total	Yearly Total
May	-	-	-	-	-	4	4	4
June 20	-	-	-	-	1	1	2	6
June 27	-	-	-	-	-	-	0	6
July 4	-	-	-	-	2	-	2	8
July 11	6	-	-	-	-	3	9	17
July 18	10	-	-	-	-	-	10	27
July 25	-	-	-	-	-	-	0	27
August 1	-	-	-	-	-	-	0	27
August 8	-	-	4	-	-	-	4	31
August 15	-	-	2	-	-	-	4	35
August 22	-	-	-	-	-	-	0	35
August 29	-	-	-	-	-	-	0	35
September 5	-	-	-	-	-	-	0	35
September 12	-	-	-	-	-	-	0	35

Source: Missouri Department of Health February 8, 1993

Table 5

MISSOURI HEAT-RELATED ILLNESS
Summer 1993

Week Ending	St. Louis	Northeast	Kansas City	Central	Southwest	Southeast	Weekly Total	Yearly Total
June 19	-	-	-	-	1	-	1	1
June 26	1	-	-	-	-	2	3	4
July 3	-	-	-	-	2	3	5	9
July 10	6	2	-	1	-	3	12	21
July 17	15	4	1	1	8	3	32	53
July 24	7	-	2	-	2	3	14	67
July 31	22	1	3	1	3	1	31	98
August 7	1	-	-	-	-	-	1	99
August 14	-	-	2	-	1	-	3	102
August 21	48	1	6	7	10	6	78	180
August 28	7	-	1	19	6	3	36	216
September 4	3	-	-	-	1	1	5	221
September 11	-	-	-	-	-	-	0	221
September 18	-	-	-	-	-	-	0	221
September 25	-	-	-	-	-	-	0	221

Source: Missouri Department of Health September 13, 1993

Table 6

MISSOURI HEAT-RELATED ILLNESS
Summer 1994

Week Ending	St. Louis	Northeast	Kansas City	Central	Southwest	Southeast	Weekly Total	Yearly Total
June 18	13	-	-	2	3	3	21	21
June 25	35	-	24	-	9	5	73	94
July 2	1	-	4	1	9	1	16	110
July 9	123	-	4	-	2	7	136	246
July 16	1	-	4	-	1	-	6	252
July 23	3	-	1	1	5	-	10	262
July 30	1	-	-	-	1	-	2	264
August 6	-	-	-	-	-	-	0	264
August 13	-	-	-	-	2	1	3	267
August 20	1	-	1	-	1	2	5	272
August 27	1	-	-	-	1	-	2	274
September 3	-	-	-	-	-	-	0	274
September 10	-	-	-	-	-	-	0	274
September 17	-	-	-	-	-	-	0	274
September 24	-	-	-	-	-	-	0	274

Source: Missouri Department of Health November 8, 1994

EARTHQUAKES

I. TYPE OF HAZARD

Earthquakes

II. DESCRIPTION OF HAZARD

Earthquakes can be defined as shifts in the earth's crust causing the surface to become unstable. This instability can manifest itself in intensity from slight tremors to large shocks. The duration can be from a few seconds up to five minutes. The period of tremors (and shocks) can last up to several months. The larger shocks can cause ground failure, landslides, liquefaction, uplifts and sand blows.

The earth's crust is made up of gigantic plates, commonly referred to as tectonic plates. These plates form what is known as lithosphere and vary in thickness from 6 1/2 miles (beneath oceans) to 40 miles (beneath mountain ranges) with an average thickness of 20 miles. These plates "float" over a partly melted layer of crust called the asthenosphere. The plates are in motion and where a plate joins another, they form boundaries. Where the plates are moving toward each other is called convergent plate boundary and when they are moving away from each other is called a divergent plate boundary. The San Andreas Fault in California is a horizontal motion boundary, where the Pacific plate is moving north while the North American plate is moving west. These movements release built up energy in the form of earthquakes, tremors and vulcanism (volcanoes). Fault lines such as the San Andreas come all the way to the surface and can be readily seen and identified. There are fault lines that do not come all the way to the surface, yet they can store and release energy when they adjust. Many of the faults in the Central United States can be characterized this way.

The subterranean faults were formed many millions of years ago on or near the surface of the earth. Subsequent to that time, these ancient faults subsided, while the areas adjacent were pushed up. As this fault zone (also known as a rift) lowered, sediments then filled in the lower areas. Under pressure, they hardened into limestones, sandstones, and shales - thus burying the rifts. With the pressures on the North Atlantic ridge affecting the eastern side of the North American plate and the movements along the San Andreas Fault by the Pacific plate, this pressure has reactivated the buried rift(s) in the Mississippi embayment. This particular rift system is now called the Reelfoot Rift.

There are eight earthquake source zones in the Central United States, two of which are located within the State of Missouri. Other zones, because of their close proximity also affect Missourians. These are the Wabash Valley Fault, Illinois Basin, and the Nemaha Uplift. The most active zone is the New Madrid Fault which runs from Northern Arkansas through Southeast Missouri and Western Tennessee and Kentucky to the Illinois side of the Ohio River Valley.

The Nemaha Uplift is of concern to Missourians because it runs parallel to the Missouri/Kansas border from Lincoln, Nebraska to Oklahoma City, Oklahoma. Its earthquakes are not as severe as the historic New Madrid fault zone, but there have been several earthquakes that have affected the Missouri side of the line.

III. HISTORICAL STATISTICS

During this decade, there was an earthquake of 3.1 Richter magnitude on March 31, 1993, close to the Cooper Nuclear Power Station in Brownville, Nebraska. It caused no damages, but was felt across the river near Rock Port, Missouri.

The most severe earthquakes occurred in the New Madrid fault zone during a period between December 16, 1811 and March 12, 1812 (see Figure 2). An engineer in Louisville, Kentucky counted over 1,850 shocks during this time, including three earthquakes of magnitude greater than 8.3 Richter magnitude. The shocks from these earthquakes could be easily felt as far away as Detroit, Michigan and Charleston, South Carolina. The area between the St. Francois River and Mississippi River south of New Madrid to Marked Tree, Arkansas showed numerous sand blows. A sand blow is a place where liquefacted alluvial soil has geysered out of the surface. Liquefaction is a phenomenon where the shaking of the ground separates the water from the soil holding it, causing the soil to behave like a dense liquid. The lack of water causes the soil to lose surface cohesion and molecules of sand from these blows to accumulate up to five feet in places. Liquefaction will cause land to lose its load bearing capacity.

Areas were uplifted as well as subsided (dropped) along the Mississippi River. Opposite New Madrid, the area around Tiptonville, Tennessee formed a dome (uplift of several yards). Immediately adjacent to the Tiptonville Dome, an area subsided to form a lake eighteen miles long and five miles wide. It is now known as Reelfoot Lake and is a tourist and recreation area.

Ground failure and landslides were apparent throughout the bluffs (Chickasaw Bluffs) alongside the Mississippi River in Kentucky and Tennessee. Many fissures were made throughout the region and one local observer recorded that the earth seemed to be rolling in waves of a few feet in height. These swells would burst, leaving wide and long fissures.

The damage to the area was so severe that Congress passed and President James Madison signed into law the first disaster relief act giving government lands in other territories to people wanting to move out of the area.

IV. MEASURE OF PROBABILITY AND SEVERITY

The Center for Earthquake Research and Information at the University of Memphis has computed conditional probabilities of a magnitude 6.0 Richter earthquake as being 40 percent to 63 percent within the next fifteen years (1985-2000). This probability increases to 86 percent to 97 percent in a 50-year period ending in 2035. With almost 12 1/2 million people living in the area, steps are being taken to reduce the hazard to the citizens and property in the area. The probability of an earthquake increases with each passing day, which makes it difficult to rate. **Based on the information from the Center of Earthquake Research and Information (University of Memphis), the probability is rated as moderate and the severity of an earthquake is rated as high.**

V. IMPACT OF THE HAZARD

The impact of earthquakes on Missouri can be significant. The three New Madrid Earthquakes of 1811-1812 can be construed as the largest that have happened in the North American continent. Although losses were limited because of the sparse population of the time, many uncounted Native American lives were lost and property was damaged to the point where resettlement became a national policy. In modern times, there have been several studies to indicate the need to mitigate for earthquakes as scholars estimate that the New Madrid Fault has the capability of generating Mercalli intensities of X (ten) in Southeast Missouri. The late Dr. Otto Nuttli of St. Louis University stated in his book, "The Effects of Earthquakes in the Central United States," that surface-wave magnitudes of 7.6 (Richter) create the largest possible earthquake that could occur anywhere along the New Madrid fault in the near future. He went on to say that there was a 7 percent probability of this occurring by the year 2000.

VI. SYNOPSIS

The chances of an earthquake increase with each day. The energy from the movement of the North American tectonic plate continues to build up along both the New Madrid and Nemaha Faults and their subsidiary fault systems. The state will have an earthquake. We don't know exactly where and we don't know exactly when, but we are overdue for a moderate earthquake. The citizens of Missouri and surrounding states will be affected by these earthquakes. There will be secondary effects from the earthquake, such as fire, building collapse, utility disruption, flooding, hazardous materials release, environmental impacts and economic disruptions/losses.

VII. MAPS OR OTHER ATTACHMENTS

The attached figures and tables show the estimated casualties and losses that one would expect from a 7.6 Richter magnitude earthquake along the New Madrid Fault.

Figure 1

PROJECTED EARTHQUAKE INTENSITIES

This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone. For a description of Projected Earthquake Intensities V through X, see following page.

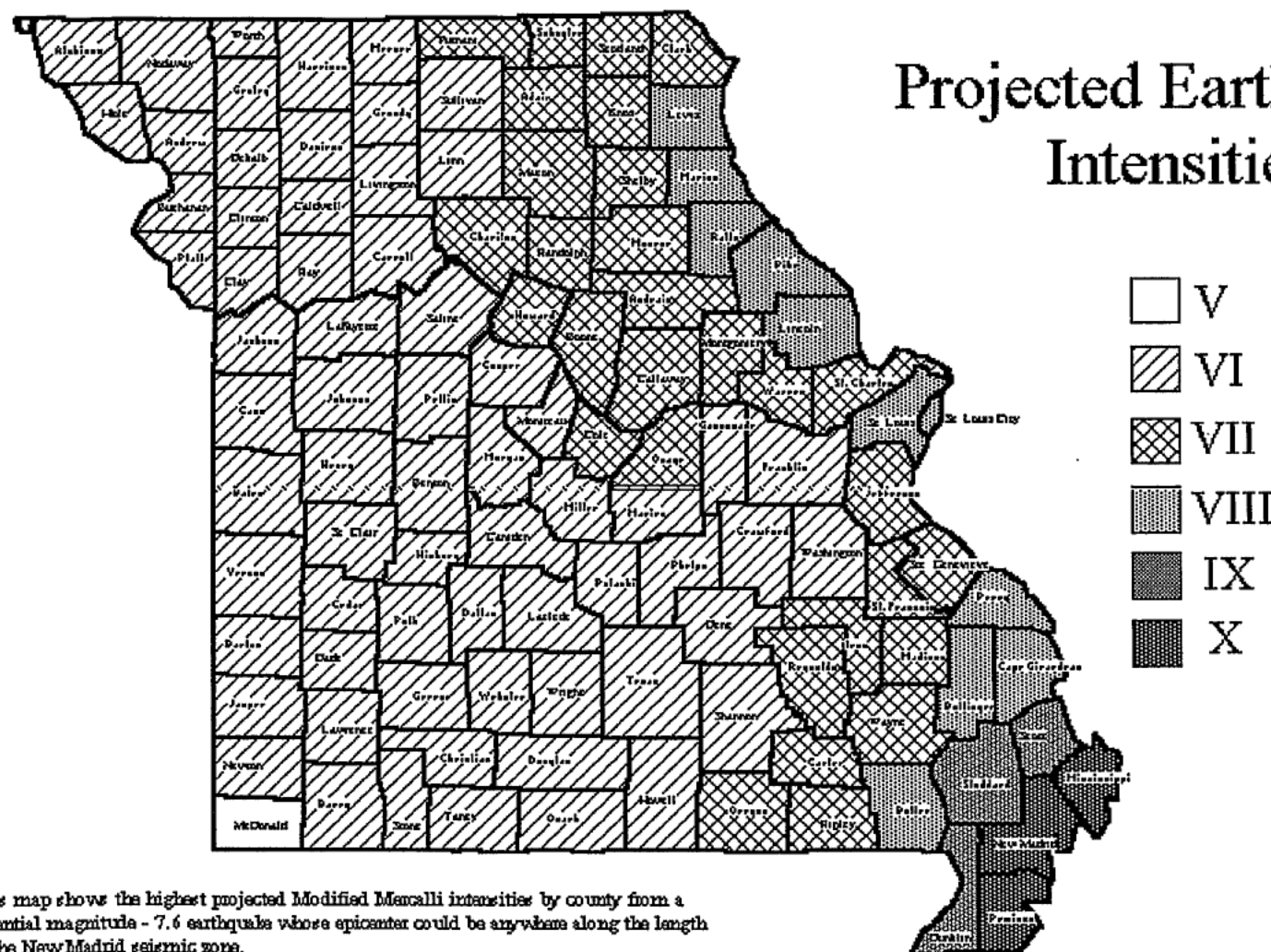


Table 1

DESCRIPTION OF PROJECTED INTENSITIES V THROUGH X

MODIFIED MERCALLI INTENSITY SCALE

- V Almost everyone feels movement. Most people are awakened. Doors swing open or closed. Dishes are broken. Pictures on the wall move. Windows crack in some cases. Small objects move or are turned over. Liquids might spill out of open containers.
- VI Everyone feels movement. Poorly built buildings are damaged slightly. Considerable quantities of dishes and glassware, and some windows are broken. People have trouble walking. Pictures fall off walls. Objects fall from shelves. Plaster in walls might crack. Some furniture is overturned. Small bells in churches, chapels and schools ring.
- VII People have difficulty standing. Considerable damage in poorly built or badly designed buildings, adobe houses, old walls, spires and others. Damage is slight to moderate in well-built buildings. Numerous windows are broken. Weak chimneys break at roof lines. Cornices from towers and high buildings fall. Loose bricks fall from buildings. Heavy furniture is overturned and damaged. Some sand and gravel stream banks cave in.
- VIII Drivers have trouble steering. Poorly built structures suffer severe damage. Ordinary substantial buildings partially collapse. Damage slight in structures especially built to withstand earthquakes. Tree branches break. Houses not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Temporary or permanent changes in springs and wells. Sand and mud is ejected in small amounts.
- IX Most buildings suffer damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks conspicuously. Reservoirs suffer severe damage.
- X Well-built wooden structures are severely damaged and some destroyed. Most masonry and frame structures are destroyed, including their foundations. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, and lakes. Railroad tracks are bent slightly. Cracks are opened in cement pavements and asphalt road surfaces.

Table 2

Moderate/Large Earthquakes Central United States

DATE	LOCALITY	AREA MILES	INTENSITY	SOURCE ZONE
Dec. 16, 1811	New Madrid, Missouri	2,000,000	XII	New Madrid Fault
Jan. 23, 1812	New Madrid, Missouri	2,000,000	XII	New Madrid Fault
Feb. 7, 1812	New Madrid, Missouri	2,000,000	XII	New Madrid Fault
June 9, 1838	Southern Illinois	Widespread	VI	Illinois Basin
Jan. 4, 1843	Western Tennessee	40,000	VIII	New Madrid Fault
Unknown, 1860	Central Minnesota	Unknown	Unknown	Colorado Lineament
Aug. 17, 1865	Southeastern Missouri	24,000	VII	New Madrid Fault
April 24, 1867	Lawrence, Kansas	300,000	VII	Nemaha Uplift
June 18, 1875	Western Ohio	40,000	VII	Cincinnati Arch
Nov. 15, 1877	Eastern Nebraska	140,000	VII	Nemaha Uplift
Oct. 22, 1882	Arkansas - Texas	135,000	VI - VII	Ouchita-Wichita Fault
July 26, 1891	Illinois - Indiana	Unknown	VI	Wabash Valley Fault
Oct. 31, 1895	Charleston, Missouri	1,000,000	VIII	New Madrid Fault
May 26, 1909	Illinois	500,000	VII	Cincinnati Arch
April 9, 1917	Eastern Missouri	200,000	VI	St. Francois Uplift
March 8, 1937	Western Ohio	150,000	VII- VIII	Cincinnati Arch
April 9, 1952	Enid, Oklahoma	140,000	VII	Nemaha Uplift
Nov. 9, 1968	South Central Illinois	580,000	VII	Wabash Valley Fault
March 24, 1976	Marked Tree, Arkansas	115,000	V - VI	New Madrid Fault
July 27, 1980	North Central Kentucky	375,000	VII	Cincinnati Arch
Jan. 31, 1986	Anna, Ohio	440,000	VI	Cincinnati Arch
June 9, 1987	Lawrenceville, Illinois	125,000	V - VI	Wabash Valley Fault
Sept. 26, 1990	Chaffee, Missouri	140,000	IV - V	New Madrid Fault
May 3, 1991	Risco, Missouri	150,000	IV - V	New Madrid Fault

Table 3

**NEW MADRID SEISMIC ZONE
MAGNITUDE 7.6 EARTHQUAKE
ESTIMATED DEATHS AND SERIOUS INJURIES***

MMI	NO.	COUNTY	POPULATION	DEATHS % OF POP.	DEATHS # OF PEOPLE	SERIOUS INJURIES % OF POP.	SERIOUS INJURIES # OF PEOPLE
X	10	New Madrid	20,735	0.200%	41	1.000%	207
X	10	Mississippi	14,324	0.200%	29	1.000%	143
X	10	Pemiscot	21,749	0.200%	43	1.000%	217
IX	9	Dunklin	32,793	0.100%	33	0.500%	164
IX	9	Stoddard	28,849	0.100%	29	0.500%	144
IX	9	Scott	39,212	0.100%	39	0.500%	196
VIII	8	Butler	39,402	0.020%	8	0.100%	39
VIII	8	Bollinger	10,667	0.020%	2	0.100%	11
VIII	8	Cape Girardeau	62,454	0.020%	12	0.100%	62
VIII	8	Perry	16,818	0.020%	3	0.100%	17
VIII	8	St. Louis	997,067	0.020%	199	0.100%	997
VII	8	St. Louis City	392,160	0.020%	78	0.100%	392
VII	7	Ripley	12,449	0.002%	0	0.010%	1
VII	7	Oregon	9,502	0.002%	0	0.010%	1
VII	7	Carter	5,699	0.002%	0	0.010%	1
VII	7	Wayne	11,936	0.002%	0	0.010%	1
VII	7	Reynolds	6,723	0.002%	0	0.010%	1

MMI	NO.	COUNTY	POPULATION	DEATHS % OF POP.	DEATHS # OF PEOPLE	SERIOUS INJURIES % OF POP.	SERIOUS INJURIES # OF PEOPLE
VII	7	Iron	10,751	0.002%	0	0.010%	1
VII	7	Madison	11,228	0.002%	0	0.010%	1
VII	7	St. Francois	49,619	0.002%	1	0.010%	5
VII	7	Ste. Genevieve	16,042	0.002%	0	0.010%	2
VII	7	Washington	20,413	0.002%	0	0.010%	2
VII	7	Jefferson	174,663	0.002%	3	0.010%	17
		Other Counties	3,152,503		27		194

*Estimates are from figures derived from CUSEIS (Central United States Earthquake Intensity Scale) published by the Center for Earthquake Studies, Southeast Missouri State University, Cape Girardeau, Missouri. The figures used are based on the 1990 Census data, utilizing the low end of estimates in the CUSEIS study.

Table 4

**NEW MADRID SEISMIC ZONE
MAGNITUDE 7.6 EARTHQUAKE
DAMAGE COSTS***

MMI	NO.	COUNTY	NUMBER OF BUILDINGS	BUILDINGS DAMAGED %	NUMBER OF BUILDINGS DAMAGED	\$M COST OF BUILDINGS (\$15K/BLDG)	\$M COST OF INFRASTRUCTURE (1.5K x % DAMAGE/PERSON
X	10	New Madrid	8,294	70.00	5,806	\$87	\$22
X	10	Mississippi	5,730	70.00	4,011	\$60	\$15
X	10	Pemiscot	8,700	70.00	6,090	\$91	\$23
IX	9	Dunklin	13,117	50.00	6,559	\$98	\$25
IX	9	Stoddard	11,540	50.00	5,770	\$87	\$22
IX	9	Scott	15,685	50.00	7,842	\$118	\$29
VIII	8	Butler	15,761	30.00	4,728	\$71	\$18
VIII	8	Bollinger	4,267	30.00	1,280	\$19	\$5
VIII	8	Capé Girardeau	24,982	30.00	7,494	\$112	\$28
VIII	8	Perry	6,727	30.00	2,018	\$30	\$8
VIII	8	St. Louis	398,827	30.00	119,648	\$1,795	\$449
VIII	8	St. Louis City	156,864	30.00	47,059	\$706	\$176
VII	7	Ripley	4,980	5.00	249	\$4	\$1
VII	7	Oregon	3,801	5.00	190	\$3	\$1
VII	7	Carter	2,280	5.00	114	\$2	\$0

MMI	NO.	COUNTY	NUMBER OF BUILDINGS (0.4 x POP.)	BUILDINGS DAMAGED %	NUMBER OF BUILDINGS DAMAGED	\$M COST OF BUILDINGS (\$15K/BLDG)	\$M COST OF INFRASTRUCTURE (1.5K x % DAMAGE/PERSON
VII	7	Wayne	4,774	5.00	239	\$4	\$1
VII	7	Reynolds	2,689	5.00	134	\$2	\$1
VII	7	Iron	4,300	5.00	215	\$3	\$1
VII	7	Madison	4,491	5.00	225	\$3	\$1
VII	7	St. Francois	19,848	5.00	992	\$15	\$4
VII	7	Ste. Genevieve	6,417	5.00	321	\$5	\$1
VII	7	Washington	8,165	5.00	408	\$6	\$2
VII	7	Jefferson	69,865	5.00	3,493	\$52	\$13
		Other Counties	1,261,001		24,506	\$368	\$92

*Estimates are from figures derived from CUSEIS (Central United States Earthquake Intensity Scale) published by the Center for Earthquake Studies, Southeast Missouri State University, Cape Girardeau, Missouri. The figures used are based on the 1990 Census data, utilizing the low end of estimates in the CUSEIS study.

Figure 2

MAGNITUDE 7.6 EARTHQUAKE

Deaths*

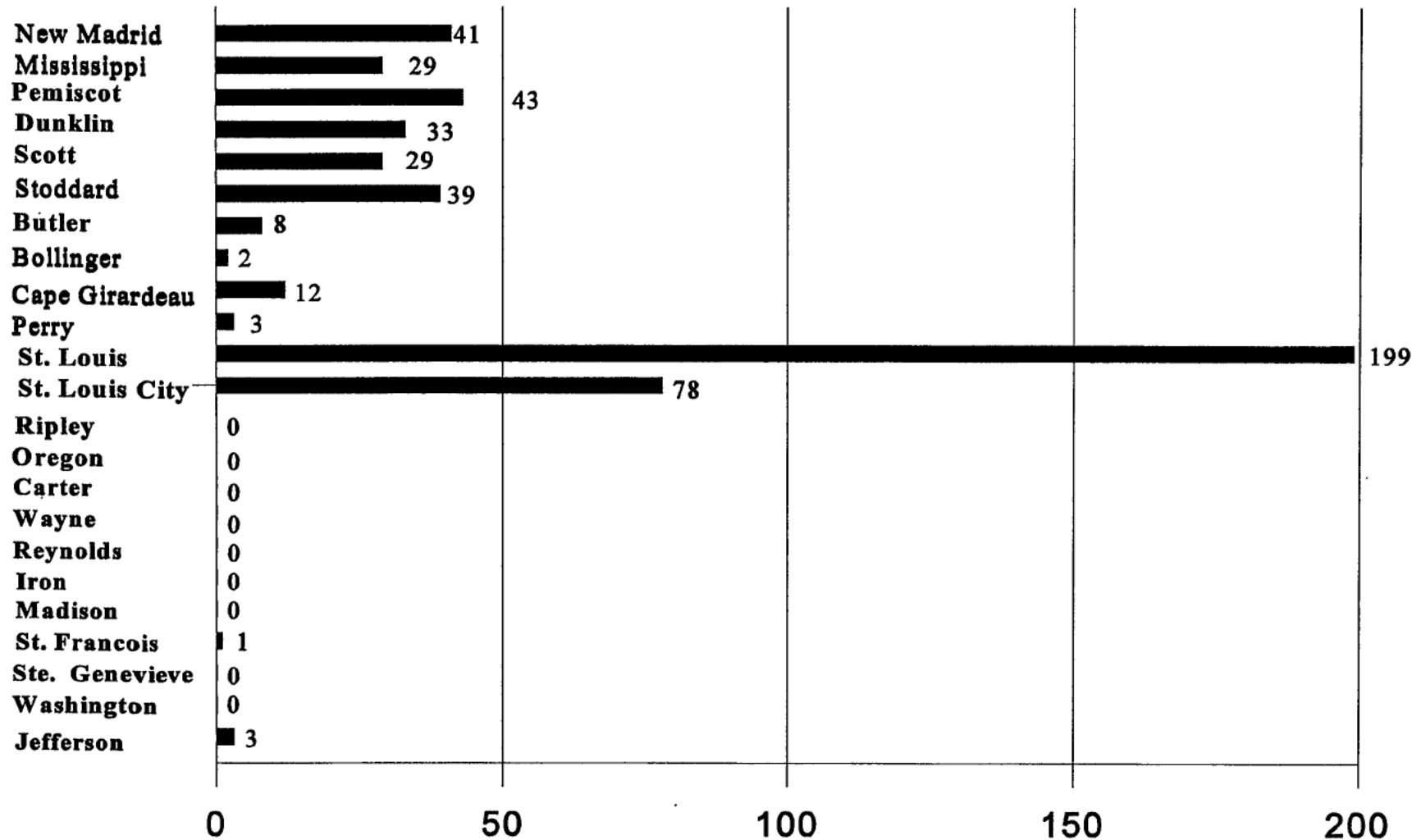


Figure 3

Magnitude 7.6 Earthquake

Serious Injuries*

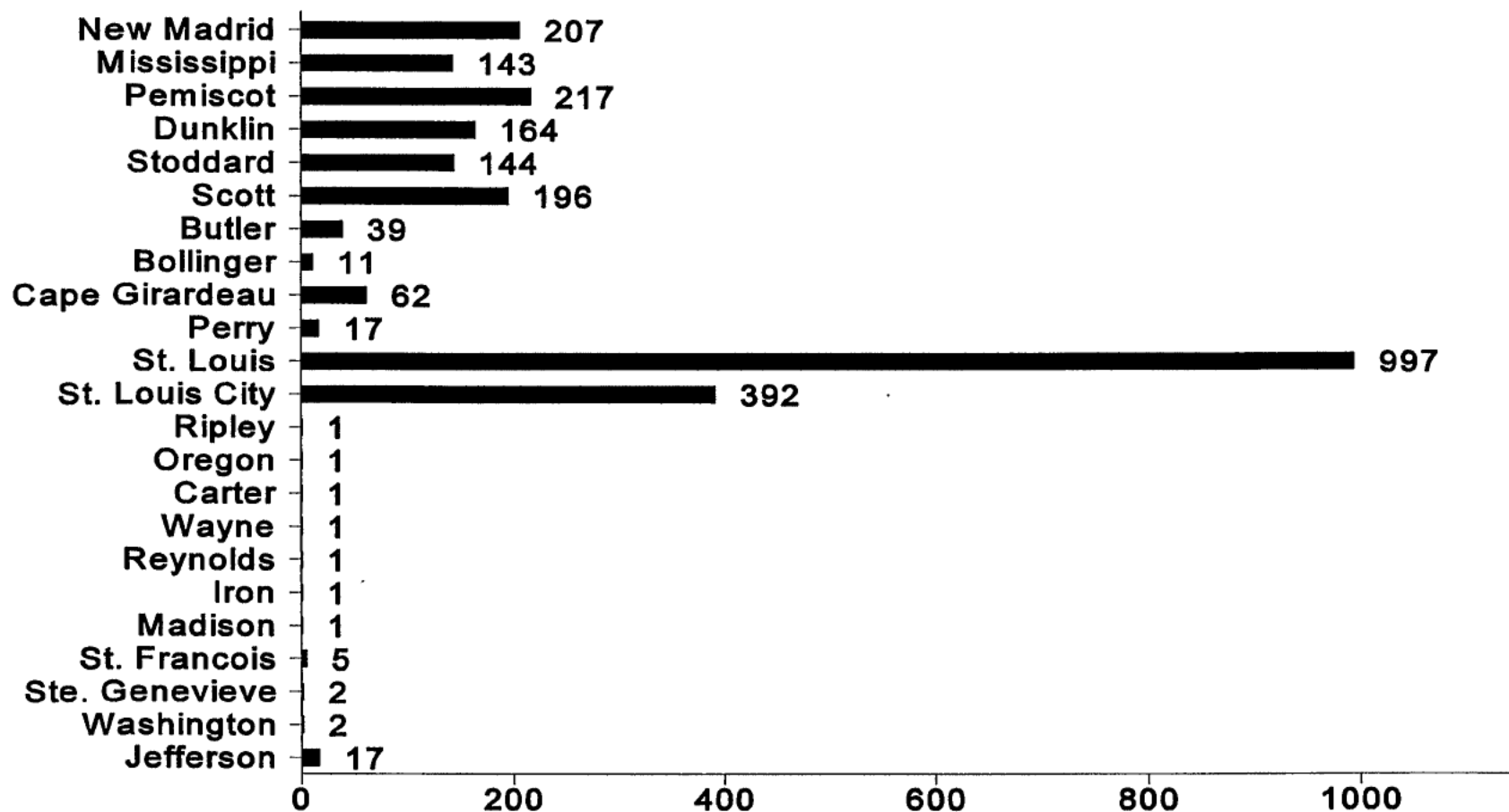


Figure 4

Magnitude 7.6 Earthquake

Dollars (Millions) to Replace Buildings*

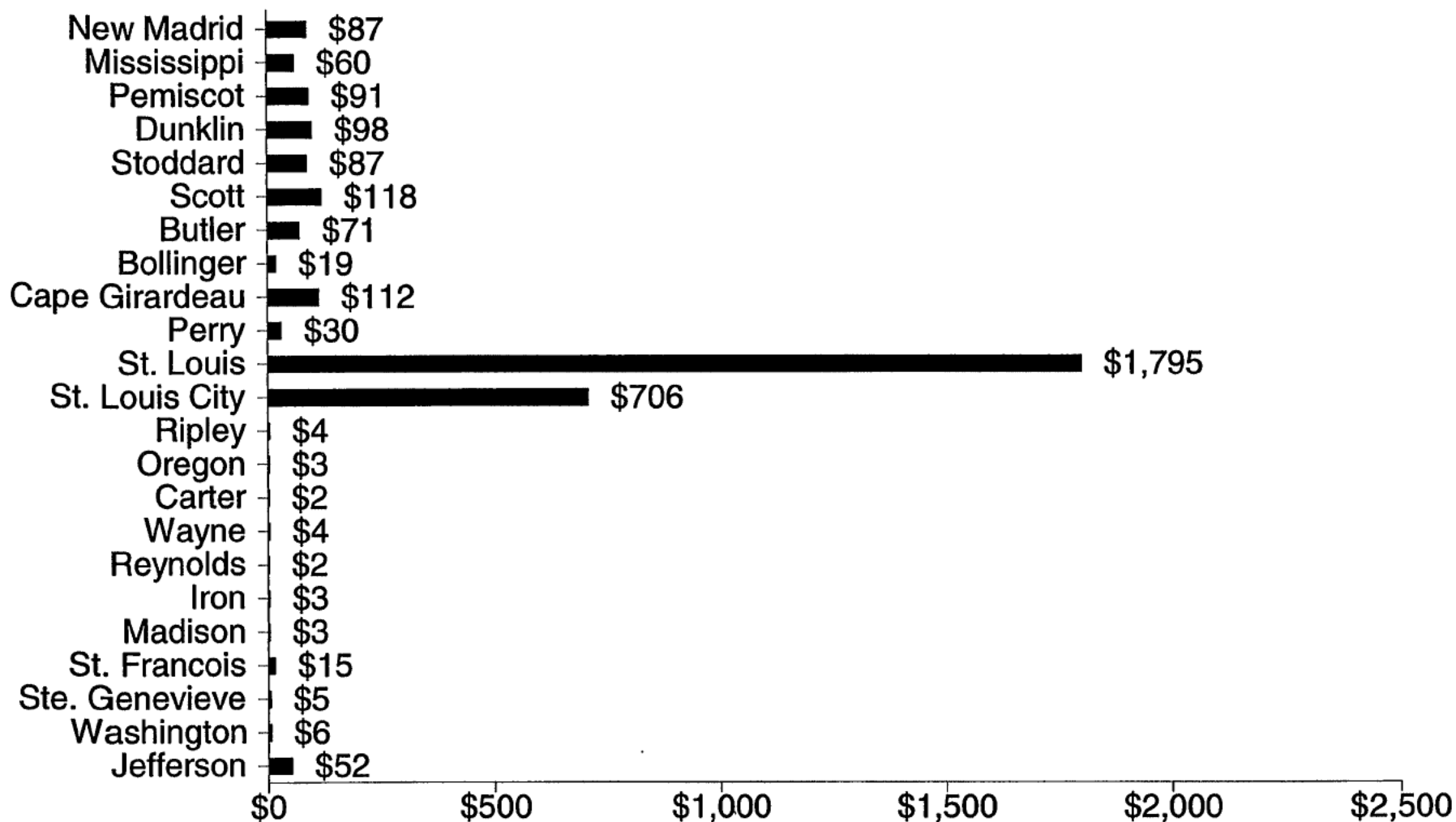
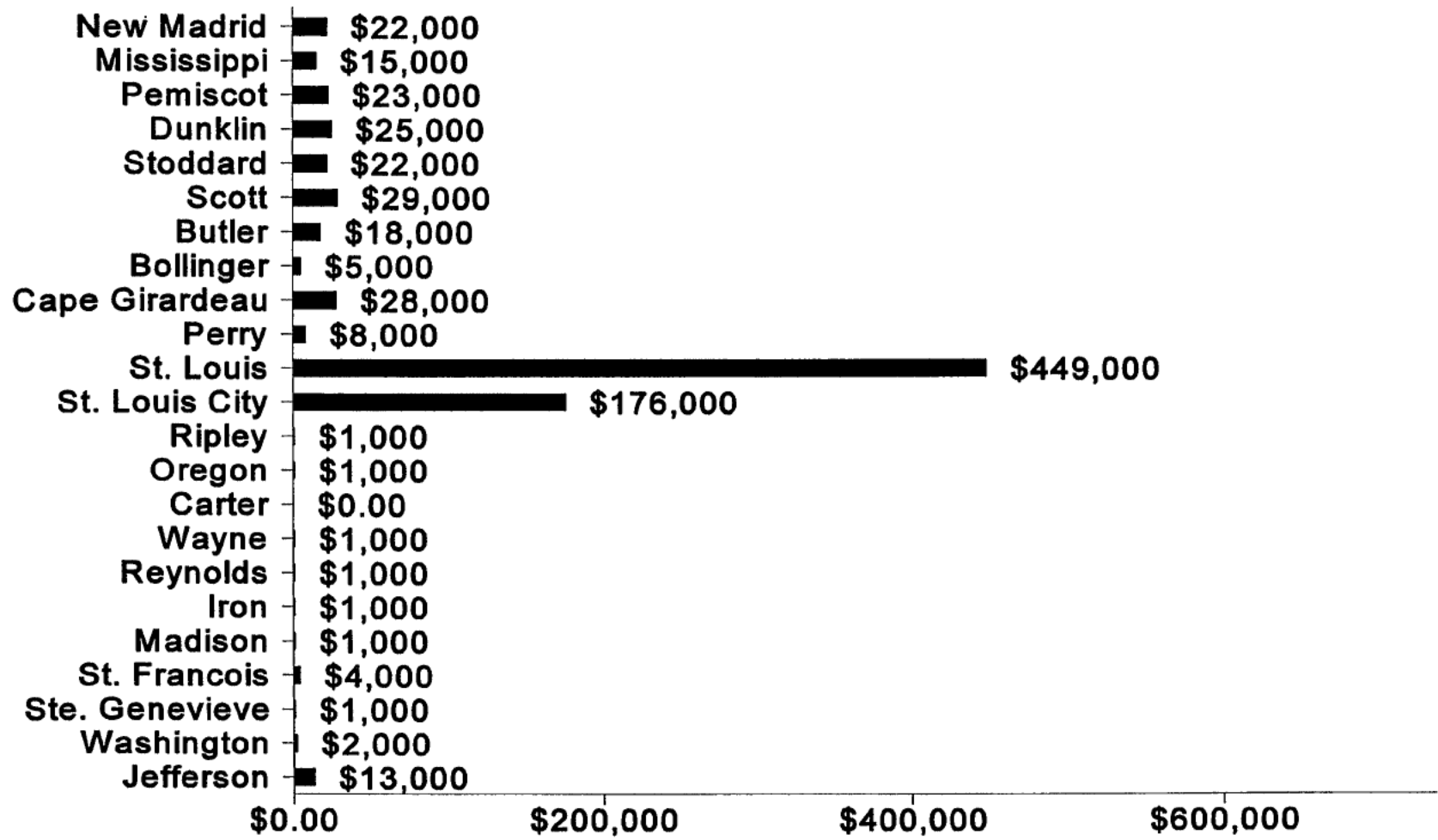


Figure 5

Magnitude 7.6 Earthquake

Dollars Damage to Utilities*



*Estimates are from figures derived from CUSEIS (Central United States Earthquake Intensity Scale) published by the Center for Earthquake Studies, Southeast Missouri State University, Cape Girardeau, Missouri. The figures used are based on the 1990 Census data, utilizing the low end range of estimates in the CUSEIS study.

DAM FAILURES

I. TYPE OF HAZARD

Dam Failures

II. DESCRIPTION OF HAZARD

Over the years dam failures have injured or killed thousands of people, and caused billions of dollars of property damage in the United States. A **dam** is defined by the National Dam Safety Act as an artificial barrier which impounds or diverts water and: (1) is more than 6 feet high and stores 50 acre feet or more, or (2) is 25 feet or more high and stores more than 15 acre feet. Based on this definition, there are over 80,000 dams in the United States. Over 95% are non-federal, with most being owned by state governments, municipalities, watershed districts, industries, lake associations, land developers, and private citizens.

Dam owners have primary responsibility for the safe design, operation and maintenance of their dams. They also have responsibility for providing early warning of problems at the dam, for developing an effective emergency action plan, and for coordinating that plan with local officials. The State has ultimate responsibility for public safety, and many states regulate construction, modification, maintenance, and operation of dams, and also ensure a dam safety program.

Dams can fail for many reasons. The most common are:

1. **Piping:** internal erosion caused by embankment leakage, foundation leakage and deterioration of pertinent structures appended to the dam.
2. **Erosion:** inadequate spillway capacity causing overtopping of the dam, flow erosion, and inadequate slope protection.
3. **Structural Failure:** caused by an earthquake, slope instability or faulty construction.

These three types of failures are often interrelated. For example, erosion, either on the surface or internal, may weaken the dam and lead to structural failure. Whereas, a structural failure may shorten the seepage path and lead to a piping failure. Observable defects that provide good evidence of potential dam failures are illustrated in Section VII of this annex.

Dam construction varies widely throughout the state. A majority of dams are of earthen construction. Missouri's mining industry has produced numerous tailing dams for the surface disposal of mine waste. These dams are made from mining material deposited in slurry form in an impoundment. Other types of earthen dams are reinforced with a core of concrete and/or asphalt. The largest dams in the state are built of reinforced concrete, and are used for hydroelectric power.

III. HISTORICAL STATISTICS

Missouri had some 4,000 recorded dams in 1995, the largest number of man-made dams of any state in the United States. The topography of the state allows lakes to be built easily and inexpensively, which accounts for the high number.

The last comprehensive inventory of dams within the state was completed in 1980. In this inventory, there were 3,528 nonfederal dams, and 85 federally controlled. A non-federal dam can be anything from a large farm pond (e.g. MFA Research Farm Lake Dam in Saline County which is 20 feet high and holds back 60 acre feet of water) to Bagnell Dam which created the Lake of the Ozarks. The great majority of nonfederal dams are either for agricultural or recreational use. Several of the older dams in the state were originally built by railroads as holding ponds for water to be used in steam locomotives. Many of these are now used as drinking water reservoirs by the towns and cities close to where they were built.

IV. MEASURE OF PROBABILITY AND SEVERITY

Dams are generally classified in three categories which identify the potential hazard to life and property should a failure occur:

1. **High Hazard** - If the dam were to fail, lives would be lost and extensive property damage could result.
2. **Moderate Hazard** - Failure could possibly result in the loss of life and appreciable property damage.
3. **Low Hazard** - Failure results in only minimal property damage.

In the 1980 Missouri Dam Survey, 681 dams, or 21% of the dams surveyed had a high hazard potential, while 754 dams, or 23% of the dams surveyed had a moderate hazard potential, and 1,818 dams, or 56% of the dams surveyed had a low hazard potential. This percentage of high hazard dams puts Missouri at about the same percentage of high hazard dams as the national average. **Based on this information, the State rates the probability as low and the severity as moderate.**

V. IMPACT OF THE HAZARD

When a dam fails, the pent-up water can be suddenly unleashed and have catastrophic effects on life and property downstream. Homes, bridges and roads can be demolished in minutes. The failure of the Buffalo Creek Dam in 1972 in West Virginia killed 125 people. The failure of the Teton Dam in 1976 in Idaho killed 14 people and caused \$1 billion in damages. There have been at least 26 recorded dam failures in 20 Missouri counties since the turn of the century. Fortunately, only one drowning has been associated with a dam failure in the state, and there has been little consequence to property.

Residents near a high or moderate hazard dam should become familiar with the dam's emergency action plans. Emergency plans written for dams include procedures for notification and coordination with local law enforcement and other governmental agencies, information on the potential inundation area, plans for warning and evacuation, and procedures for making emergency repairs.

Within the State of Missouri, the Department of Natural Resources maintains a Dam and Safety Program within the Division of Geology and Land Survey. The objective of this program is to insure that dams are safely constructed, operated, and maintained pursuant to Chapter 236 Revised Statutes of Missouri. However, since a dam must be 35 feet or higher to be regulated, only about 20% of Missouri's Dams are regulated under Missouri law. However, the State has for many years encouraged dam owners to do owner inspections for those dams not under Chapter 236 RSMO.

VI. SYNOPSIS

Dam breaks are caused most often by failure of the structure itself. However, flooding is the most common hazard interacting with dam failure. Prolonged rains and flooding can saturate earthen dams, for example, producing much the same breaching effect as that which occurs with earthen levees. Flooding can also result in overtopping of dams when the spillway and reservoir storage capacities are exceeded by the excess water. A large slide may develop in either the upstream or downstream slope of the embankment, and threaten to release the impounded water. Complete structural collapse can occur, especially as a result of an earthquake, or severe tremors.

Actual dam failure can not only result in loss of life, but also considerable loss of capital investment, loss of income, and property damage. Loss of the reservoir itself can cause hardship for those dependent on it for their livelihood or water supply. Loss of the reservoir itself can also upset the ecological balance of the area as well.

VII. MAPS OR OTHER ATTACHMENTS

Illustrations: Figure 1, Observable Defects; Table 1, Dams In Missouri By Purpose; Table 2, and Figure 2, Dams In Missouri By County

Figure 1

OBSERVABLE DEFECTS

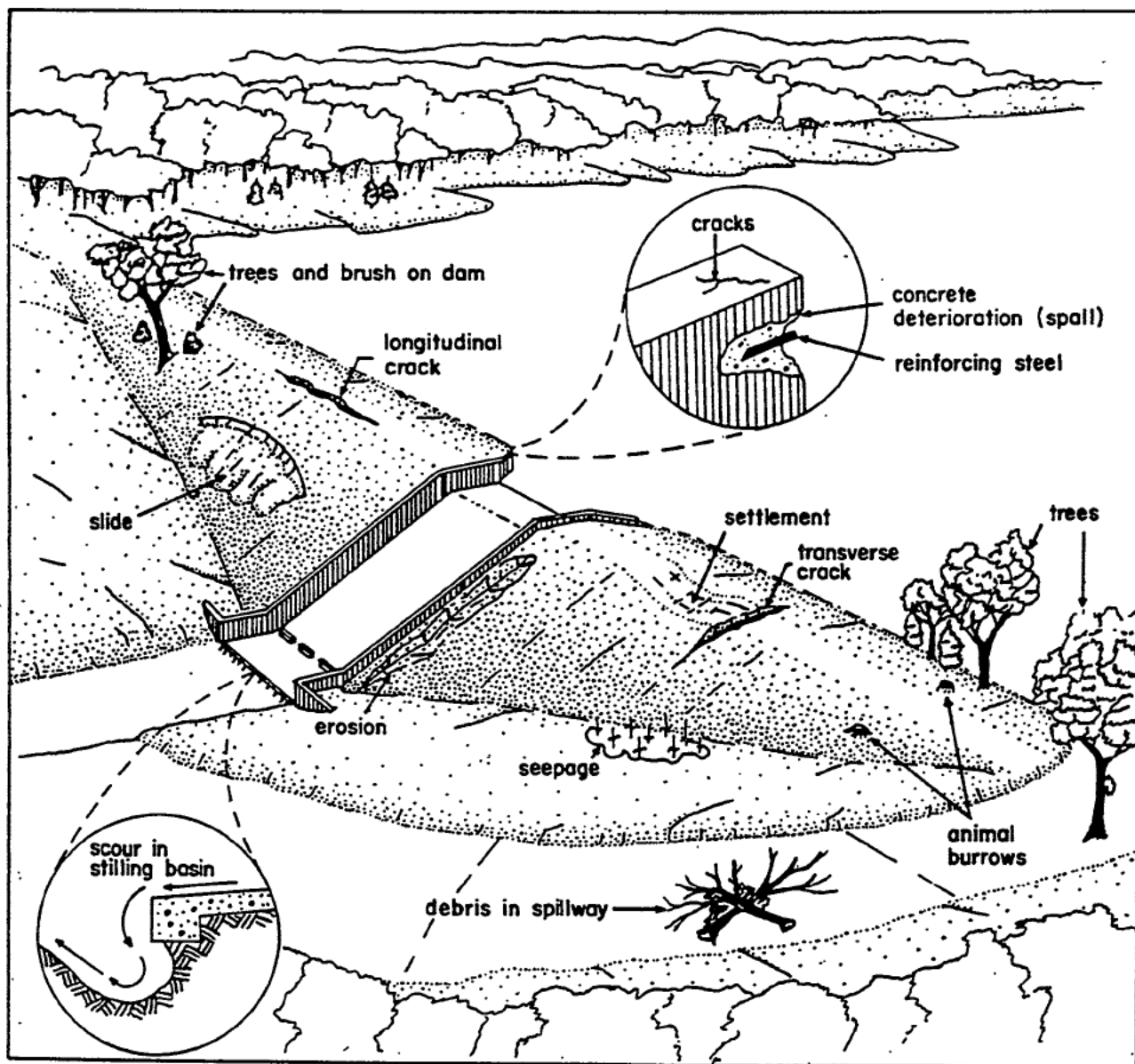


Table 1

Dams in Missouri by Purpose

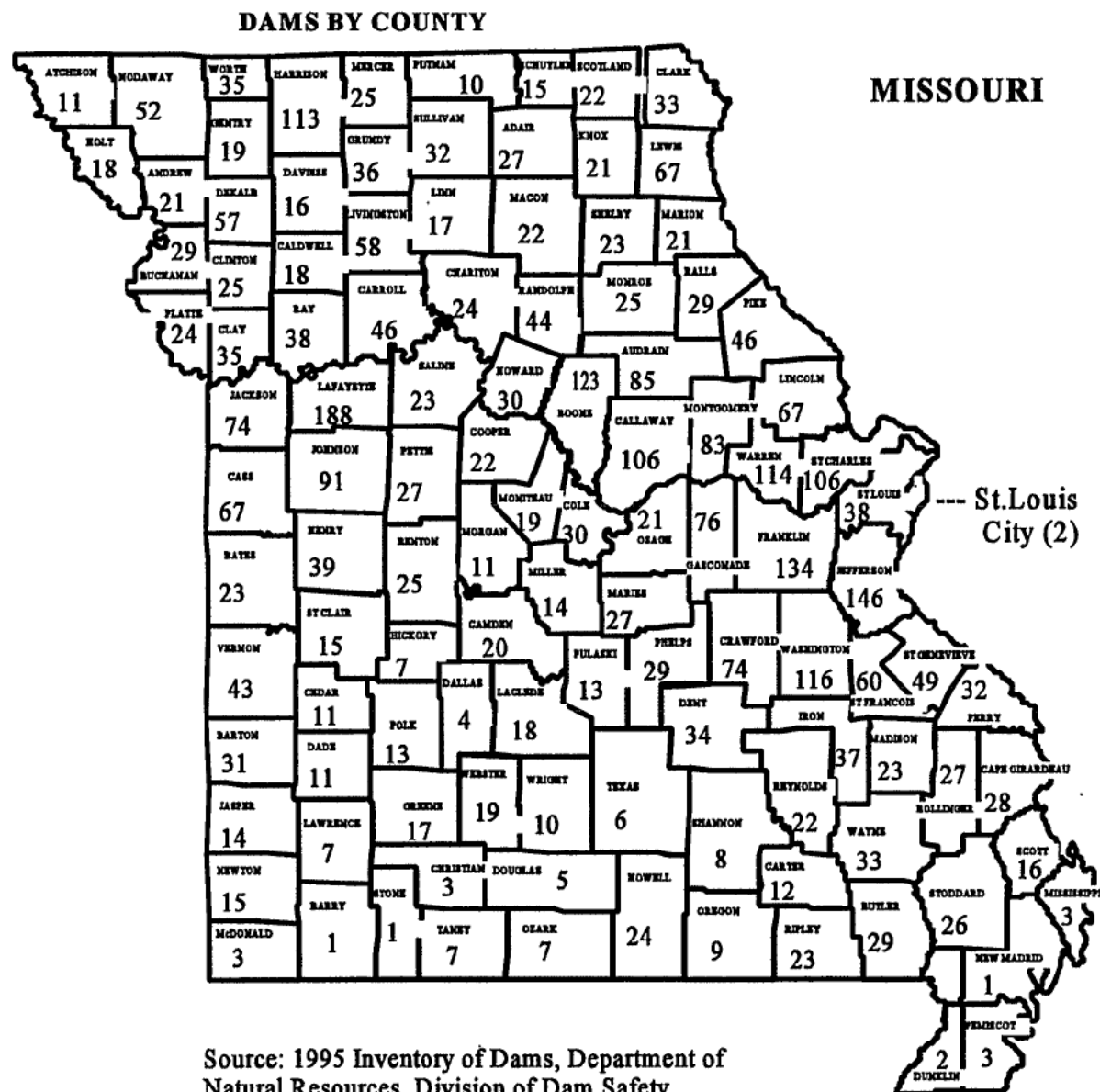
	<u>Number</u>	<u>Percent</u>
Fire and Farm Ponds	381	10.8%
Flood Control	285	8.0%
Hydoelectric	8	0.2%
Irrigation	296	8.4%
Navigation	7	0.2%
Recreation	1,826	51.6%
Tailings and Others	487	13.8%
Water Supply	243	6.9%
Undetermined	8	0.1%

Table 2

COUNTY	NO. OF DAMS	COUNTY	NO. OF DAMS
Adair	27	Daviess	16
Andrew	21	DeKalb	57
Atchison	11	Dent	34
Audrain	85	Douglas	5
Barry	1	Dunklin	2
Barton	31	Franklin	134
Bates	23	Gasconade	76
Benton	25	Gentry	19
Bollinger	27	Greene	17
Boone	123	Grundy	36
Buchanan	29	Harrison	113
Butler	29	Henry	39
Caldwell	18	Hickory	7
Callaway	106	Holt	18
Camden	20	Howard	30
Cape Girardeau	28	Howell	24
Carroll	46	Iron	37
Carter	12	Jackson	74
Cass	67	Jasper	14
Cedar	11	Jefferson	146
Chariton	24	Johnson	91
Christian	3	Knox	21
Clark	33	Laclede	18
Clay	35	Lafayette	188
Clinton	25	Lawrence	7
Cole	30	Lewis	67
Cooper	22	Lincoln	67
Crawford	74	Linn	17
Dade	11	Livingston	58
Dallas	4	McDonald	3

COUNTY	NO. OF DAMS	COUNTY	NO. OF DAMS
Macon	22	Ray	38
Madison	23	Reynolds	22
Maries	27	Ripley	23
Marion	21	St. Charles	106
Mercer	25	St. Clair	15
Miller	14	St. Francois	60
Mississippi	3	St. Genevieve	49
Moniteau	19	St. Louis	38
Monroe	25	St. Louis City	2
Montgomery	83	Saline	23
Morgan	11	Schuyler	15
New Madrid	1	Scotland	22
Newton	15	Scott	16
Nodaway	52	Shannon	8
Oregon	9	Shelby	23
Osage	21	Stoddard	26
Ozark	7	Stone	1
Pemiscot	3	Sullivan	32
Perry	32	Taney	7
Pettis	27	Texas	6
Phelps	29	Vernon	43
Pike	46	Warren	114
Platte	24	Washington	116
Polk	13	Wayne	33
Pulaski	13	Webster	19
Putnam	10	Worth	35
Ralls	29	Wright	10
Randolph	44		

Figure 2



**UTILITIES
(INTERRUPTIONS AND SYSTEM
FAILURES)**

I. TYPE OF HAZARD

Utilities-Interruptions and System Failures

II. DESCRIPTION OF HAZARD

Utility interruptions and failures may include electrical power, natural gas, public water and communications systems. All of these systems or a combination of these utility systems exist virtually throughout the state. Many utilities are localized and serve only one community, while other utilities serve a regional area. Utilities are often dispersed over a wide area and many have facilities located throughout their service area. For example, many electric companies have multiple generating facilities which can redistribute power via transmission lines as they are connected to load stations. Therefore, power can be redistributed, if needed, so power is lost to as limited an area as possible. Many water companies have some type of back-up system such as water impoundments, other deep wells or hook-up arrangements with other water companies. Similar switching and rerouting capabilities may exist with communications and natural gas utilities. Utility systems exist everywhere and are subject to damage from digging, fire, traffic accidents, and severe weather, including flooding and other day-to-day events. Many utilities utilize emergency batteries or generators to provide back up power for high priority equipment.

III. HISTORICAL STATISTICS

Because utilities exist virtually everywhere in the state, damage to utilities may occur frequently. This may be due to a backhoe cutting a buried line, an accident involving a motor vehicle, a flood or other severe weather. Many of these interruptions or failures go unreported to the Public Service Commission and no definitive reporting system is readily available. Therefore, limited statistical information is available. During December 1994, an estimated 26,000 customers of various Rural Electric Cooperatives were without electric power due to downed lines and broken poles as a result of a severe ice storm in northern Missouri. This does not include various municipal utility customers.

During the flood of 1993, telecommunications companies proved their adaptability by using cellular service to replace wire line service in areas where service could not be restored in a timely manner. One Local Exchange Company (LEC) utilized a trailer with cellular pay phones where the land lines were interrupted. Another company replaced analog subscriber carrier service on a temporary basis with site based cellular service. Short haul portable microwave was also utilized to replace copper lines lost during the flood.

IV. MEASURE OF PROBABILITY AND SEVERITY

Because utilities exist throughout the state and are vulnerable to interruptions or failures, there is a high probability that this hazard may occur at anytime or anywhere throughout the state. In many cases these are small isolated events well within the capabilities of the local utility. Therefore, the degree of severity of these day-to-day events may be considered low. Due to long

range planning, regulation and diligence of the utility operators, major interruptions resulting in a high degree of severity are few and far between. Recent regulatory, planning and structural initiatives designed to minimize interruptions and failures are listed below.

V. IMPACT OF THE HAZARD

COMMUNICATIONS

During 1990, the Telecommunications Staff of the Public Service Commission requested that Local Exchange Companies (LEC) submit a plan for disaster recovery. Every LEC in the state submitted a plan that lists practices and procedures for any kind of disaster whether natural or man made.

In order to mitigate the damage of earthquakes, the LECs added bracing to all their central offices for their switching equipment and batteries. Since earthquakes or other disasters may affect electrical service which is essential for operations, companies have provided on site generators or made contingency arrangements to provide them in a disaster. Such generators are needed to power their central offices prior to exhaustion of emergency battery supplies, which may last about eight hours. During the flood of 1993, one LEC provided emergency power to a central office which was isolated by flood waters. This was accomplished by driving a flat bed truck into the water with a diesel generator mounted on the bed. The generator was fueled by boat.

Since floods pose a threat to telephone service, most companies with buried cable in the flood-plain are replacing conventional telephone pedestals with a flood resistant telephone pedestal which protects the cable during a flood of short duration.

Fiber optic is a proven form of high capacity communications. It is also vulnerable to accidental cuts. Telephone companies have mitigated this hazard by clearly marking fiber routes, and conducting weekly patrols by vehicle or air. In addition to that precaution, most companies are presently building a fiber ring for their fiber routes to protect continuity of their service in the event of an accidental cut.

Vulnerability of buried cable has always been a problem, but in recent years a private company legislated by Senate Bill Numbers 214 and 264 called "One Call" has made a difference for telecommunication cable routes. Presently, most LECs in the state have their facilities on record with the "One Call" agency. Contractors are encouraged to call "One Call" before plowing, excavating or trenching.

Another mitigation solution that is available but has not yet been used is the availability of a portable switch, should a working switch be destroyed. Presently, this solution is available through the Northern Telecom and Falcon Communication companies.

NATURAL GAS

All natural gas system operators in the state operate under the jurisdiction of the Missouri Public Service Commission (PSC). These operators must comply with the Commission's Pipeline Safety Regulations that include emergency response procedures to pipeline emergencies and natural disasters. Natural gas system operators have plans on file with the PSC. Part of this plan includes an index of utilities and their location in the state.

In 1989, House Bill 938 provided the Commission with additional legal power to enforce the Pipeline Safety Regulations. In 1990, due in part to the Iben Browning earthquake projection, all utilities were mandated by the Commission to develop a natural disaster plan to include earthquakes and file the plan with the Commission. The Commission developed its own disaster plan to enable the Commission to respond to a disaster causing an interruption or failure of a utility service. The Iben Browning earthquake projection created a new awareness for the necessity for disaster response and recovery. Several natural gas companies have stored emergency equipment and survival rations in protected locations. This also resulted in a new demand for excess flow and motion sensing valves on natural gas service lines. Operators also reviewed, updated or increased their mutual aid agreements with other utilities and contractors.

Senate Bill numbers 214 and 264, in 1990 required all owners and operators of underground pipeline facilities to participate in the Missouri "One Call" notification center. These bills altered the original Chapter 319 Damage Prevention Act and added a penalty clause. This participation provides for the location of pipeline facilities after notification by the excavator and before any excavation work begins.

VI. SYNOPSIS

Utility companies are generally well-prepared to deal with day-to-day outages. The earthquake threat to statewide and multi-states' utilities is the greatest concern to the integrity and operability of Missouri's utilities. Planning, regulation, mitigation and mutual aid are all just a few tools available to reduce, speed recovery and prevent utility interruptions and failures.

VII. MAPS OR OTHER ATTACHMENTS

An earthquake map showing all pipelines and electrical transmission lines is on file at State Emergency Management Agency, Earthquake Section.

**FIRES
(STRUCTURAL, URBAN
AND WILD)**

I. TYPE OF HAZARD

Fires (Structural, Urban and Wild)

II. DESCRIPTION OF HAZARD

Fires can range in scope to include structural, urban, and wild. For the purpose of this analysis, structural and urban fires will be considered in one category with wild fires, including forest, prairie, and grassland, considered separately.

Structure fires are a major problem which affect any area of the state. The Missouri Division of Fire Safety indicates that approximately 80 percent of the fire departments in Missouri are staffed with volunteers dedicated to the task of fire prevention and suppression. Whether paid or volunteer, these departments are often limited by lack of resources and financial assistance. The impact of fire to a single story building in a small community may be as great as that of a larger fire to a multi-story building in a large city.

Since fires can occur anywhere in the state, the Division of Fire Safety has actively promoted the enactment of a statewide fire code. Although no statewide code has been enacted, successful legislative efforts to improve fire safety include:

- A. Fire, safety, health and sanitation inspections of Child Care Facilities (RSM 210.252)
- B. Boiler and Pressure Vessel Safety Act (RSM 650.200)
- C. Elevator Safety Act (RSM 701.350)

Fires impact many aspects of society in terms of economic, social and other indirect costs. According to the Division of Fire Safety, the most costly crime in the state is arson. This should be a great concern to citizens, law enforcement, the judicial system and the fire service. Fire caused by arson impacts citizens through higher insurance premiums, jobs lost, loss of lives, injuries and property loss. According to the Division of Fire Safety in 1993, 1192 cases were investigated with over 50 percent being incendiary or arson. Primary duties of the Missouri State Fire Marshal include the investigation of fires, explosions and any related occurrences. The investigative staff is responsible to investigate any fire requested by fire service and law enforcement within the state. This also includes explosions, bombings and all other related offenses.

Presently, the Division of Fire Safety investigative staff includes one deputy chief, two regional chiefs and 15 field investigators. This staff must cover all 114 counties and is dedicated to assist any local or state agency and conduct a quality investigation. The investigators are trained in several fields of expertise including: arson for fraud, explosives recognition and post blast training.

The Division of Fire Safety Training Unit develops and oversees the training curriculum being provided regionally for state certification for fire fighters, fire investigators, fire inspectors and fire service instructors. Although fire fighter certification is not mandatory in Missouri, there are currently over 6,100 individuals certified by the Division of Fire Safety.

Also, Fire Safety has initiated a state-wide mutual aid system. This system enhances rural (volunteer) or city fire departments ability to handle a major fire within their jurisdiction. To compliment the state-wide mutual aid system, an incident command system (ICS) overhead team concept has been developed throughout the state. This should assist the rural/city fire departments in the management of a major fire disaster.

State statutes also give the Investigative Unit responsibility for inspection and permit fees for fireworks inspections. Fireworks licensing for 1993 involved over 3,000 permits. Illegal fireworks are a concern because they can be dangerous, causing loss of lives, severe injuries and property damage.

Forest and grassland fires can and have occurred on any day throughout the year. The majority of the fires, however, and the greatest acreage loss will occur during the spring fire season, which is normally between February 15 and May 10. The length and severity of this burning period depends on the weather conditions. Spring in Missouri is noted for its low humidity and high winds. These conditions, together with below normal precipitation and high temperatures, result in extreme high fire danger. Not only is this the time of the year when fires are most difficult to control and suppress, it is also the time when most fire starts occur. Spring is the time of the year when rural residents normally burn their garden spots, brush piles, etc. Many landowners also still believe it is necessary to burn the woods in the spring of the year in order to get more grass, kill ticks, and "get rid of" the brush. Therefore, with the possibility of extremely high fire danger and the chances of a large number of fires starting, the spring months are the most dangerous for a wildfire standpoint. The second most critical period of the year is in the late fall. Depending on the weather conditions, there is a possibility of a sizeable number of fires occurring between mid-October and late November.

III. HISTORICAL STATISTICS

Because building structures exist anywhere people live and work, fires can occur any time and anywhere throughout the state. Frequency of events depend on a wide range of factors. These factors could include and are not limited to: population/building density, building use, lack of fire codes, lack of enforcement when fire codes exists, fire safety practices or lack of by building occupants, lack of adequately equipped fire departments and criminal intent related to arson.

Frequency of structural fire data may include the "1993 Missouri Incident Reporting System Statistics" data provided by the Division of Fire Safety. According to Fire Safety, 250 out of approximately 900 fire departments reported the data utilized to compile the Missouri Incident Report statistics. Considering that 250 of approximately 900 fire departments completed the report and that just over 3,000 fires were classified as "Vehicles" and over 3,900 as "All Other", definitive conclusions are not possible. However, it is readily apparent that fire departments, law enforcement and other agencies spent considerable manpower and funding to respond to and investigate structural fires.

The Forest Division of the Missouri Department of Conservation is responsible for protecting the privately-owned and state-owned woods and grasslands from wildfires. To accomplish this task, intensive forest fire protection districts have been established in the more heavily-timbered southern part of the state. At the present time, 17 forest districts afford intensive fire protection to approximately one-half of the state or about 16 million acres. Within these districts fairly accurate forest and grassland fire statistics are available from the Missouri Department of Conversation. In a typical year, there are approximately 3,500 wildfires.

In north and west central Missouri, the Missouri Department of Conversation has limited firefighting forces. Forestry Division personnel, however, provide training and limited Federal excess equipment to the many volunteer rural fire departments. Accurate fire statistics are not available for this part of the state.

IV. MEASURE OF PROBABILITY AND SEVERITY

Even with the limited data reported from the "1993 Missouri Incident Reporting System Statistics", **the probability of structural fire is quite high.** These statistics indicate an estimated loss of \$43 million. The Department of Health reported fire as the cause of one hundred (100) deaths in 1993 and one hundred twenty-seven (127) in 1992. Therefore, **severity could be considered moderate.**

The probability of wild fires (forest, prairie and grassland) is considered moderate overall, but may increase to high during certain periods, such as spring, late fall, or under conditions of excessive heat, dryness, and/or drought. **The severity would be considered low to moderate.**

The reports show that each year a few buildings burn from fires that start in woods and grassland. There is also an occasional fatality resulting from natural cover fires. These fatalities, however, usually involve elderly person attempting to suppress a fire which has escaped control. Death in most cases is caused by exertion or a heart attack.

Natural cover fires in Missouri are not as spectacular, do not receive the publicity, and are less likely to constitute a conflagration as fires in western states. They can and do, however, have an impact on timber production, watershed protection, air quality, and aesthetic values.

Debris burning (fires resulting from land clearing, burning trash, range, stubble, right-of-way, logging slash, etc.) is the major cause of woods and grass fires in Missouri. Incendiary fires (fires willfully set by anyone on property not owned or controlled by him, and without the consent of the owner) continues to rank second in the number of wildfires that occur each year.

V. IMPACT OF THE HAZARD

It is apparent that structural and urban fires are a day to day occurrence throughout the state. Approximately one hundred fatalities occur annually, as well as numerous injuries affecting the lives of the victims, their families and many others--especially those of fire and medical services. Unlike

other disasters, structural fires are often insidious and despicable due to the prevalence of arson. All citizens pay the costs of arson whether through increased insurance rates, higher costs to maintain fire and medical services and the criminal justice system.

VI. SYNOPSIS

With sufficient mutual aid, local fire services have adequate day to day fire service capabilities. The greatest risk of interaction with other hazards may be a damaging earthquake. The possibility of numerous fire and reduced firefighting capabilities greatly increase the severity of structural fires.

VII. MAPS OR OTHER ATTACHMENTS

Attachment 1 - Missouri Incident Reporting System Statistics

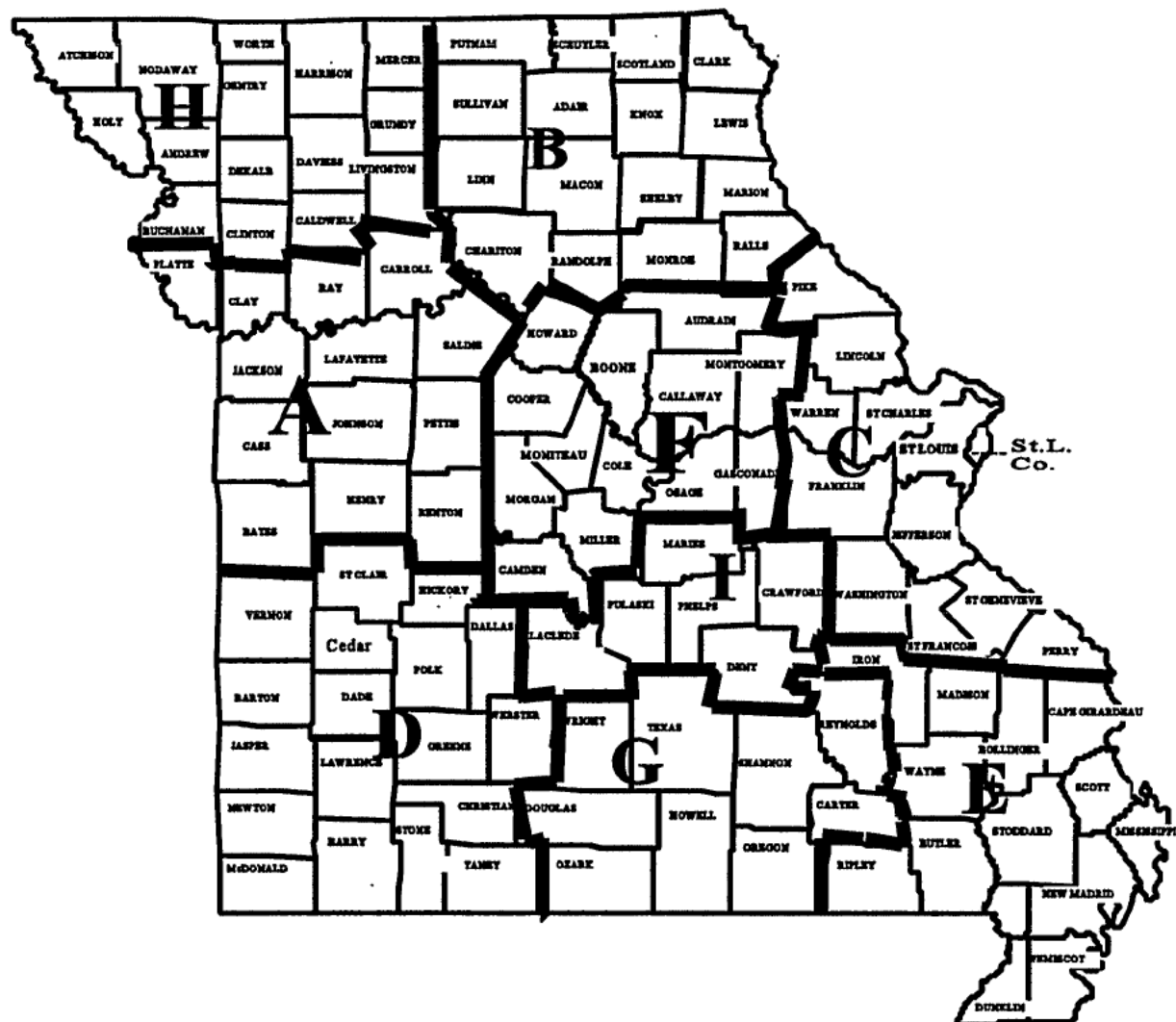
Attachment 2 - Fire/Rescue Mutual Aid Regions

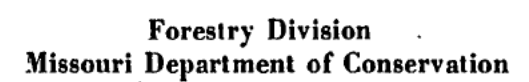
Attachment 3 - Forest Fire Protection District Map

Attachment 1
1993 Missouri Incident Reporting System Statistics

Fixed Property Use	No. of Fires	Estimated Loss
Private Dwellings	2789	\$29,564,000.00
Multiple Dwellings	287	\$ 3,070,100.00
Business	131	\$ 1,916,050.00
Manufacturing	72	\$ 2,102,000.00
Schools and Hospitals	64	\$ 726,100.00
Barns, Crops, etc.	110	\$ 2,481,100.00
Other Buildings	163	\$ 3,949,550.00
Vehicles	3011	\$ 7,095,550.00
All Other	3985	\$ 3,142,850.00
TOTALS	10621	\$54,047,300.00

FIRE/RESCUE MUTUAL AID REGIONS





NUCLEAR POWER PLANTS (FIXED NUCLEAR FACILITIES)

I. TYPE OF HAZARD

Nuclear Power Plants (Fixed Nuclear Facilities)

II. DESCRIPTION OF HAZARD

There are presently four fixed nuclear facilities or reactors that under extreme circumstances and conditions could pose a threat to the general public of Missouri. These four reactors fall into two categories: Research Reactors and Commercial Nuclear Power Reactors. The first category, Research Reactors, only represent a hazard to personnel or the public on site of the facility. Therefore, they are not included in state radiological plans involving off-site emergency preparedness. In the second category, Commercial Nuclear Power Reactors, a worst case scenario where a significant release of radioactive material has occurred could force the evacuation of the general population within a 10-mile radius of the facility. A release of this magnitude could also contaminate food sources out to a 50-mile radius.

Releases from nuclear plant sites are dependent on the nature of the accident type, reactor design, and meteorological conditions during the release. The Nuclear Regulatory Commission (NRC) and Federal Emergency Management Agency (FEMA) have developed regulatory guidances that both the state and utility must meet to ensure the health and safety of the general population within the 10-mile Emergency Planning Zone (EPZ). There are four classes of Emergency Action Levels that are used for early notification of the severity of the incident, with clear instructions for off-site actions of emergency organizations within the EPZ. The four emergency classifications listed in progression of severity are:

Notification of Unusual Event

This classification describes unusual events that are in process or have occurred which indicate a potential degradation of the level of safety of the plant. No releases of radioactive material requiring off-site response or monitoring are expected unless further degradation of safety systems occur.

Alert

This classification describes unusual events that are in process or have occurred which indicate a potential degradation of the level of safety of the plant. Any releases are expected to be limited to small fractions of the Environmental Protection Agency (EPA) Protective Action Guideline (PAG) exposure levels.

Site Area Emergency

This classification level describes events in process or having occurred which involve actual or likely major failures of the plant functions needed for protection of the public. Any releases are not expected to exceed EPA PAG exposure levels except near the site boundary.

General Emergency

This classification describes an event in process or having occurred which involves actual or imminent substantial core degradation or melting, with the potential for loss of containment integrity. Releases can reasonably be expected to exceed the EPA PAG exposure levels off-site for more than the immediate site area.

III. HISTORICAL STATISTICS

Research Reactors

There are two research reactors located in the State of Missouri: the University of Missouri-Rolla Reactor (UMRR) and the University of Missouri Research Reactor (MURR). The maximum hypothetical accident from either research reactor would only place at risk personnel working at the facilities or the public within the site boundary of the respective facilities. Both research reactors have Emergency Plans approved by the Nuclear Regulatory Commission (NRC) that conform with regulatory requirements in 10 CFR 50, Appendix E, following the guidance provided by Revision I to NRC Regulatory Guide 2.6, Emergency Planning for Research and Test Reactors, March 1982, and ANSI/ANS-15.16, Emergency Planning for Research and Test Research Reactors, November 29, 1981.

UMRR

UMRR is a water moderated pool type reactor licensed to operate at 200 KW. The UMRR is used for training and research purposes. Because the reactor is mainly used for training, it is not operated for long periods of time. The reactor is located on the east side of the Rolla campus near 14th Street and Pine Street in Rolla, Missouri. Due to the low power of licensing (200 KW), prevailing standards and guidelines do not require the establishing of an emergency planning zone. Therefore, no classification higher than a Site Area Emergency has been included in their emergency plans. The UMRR has been in operation since December 1961 and has never had an incident that would be considered an emergency action level.

MURR

MURR is a 10 MW pressurized water moderated pool type reactor with a containment building. The MURR is utilized for research, training, and services to the four campuses of the University of Missouri system, other universities, government agencies, and private industry as well. The reactor is located on a 550-acre tract of land south of the University of Missouri-Columbia campus on Providence Road. The MURR has an emergency planning zone of 100-meter radius from the exhaust stack. There have been no credible accidents identified for the MURR facility that would result in exceeding the classification of Notification of Unusual Events. As a result, no classification higher than a Site Area Emergency is included in the emergency plan for the MURR. The MURR has been in operation since October 1967. The reactor averages 8,060 hours of operation per year (155 hours per week) at peak flux due to the service work that it performs. The MURR has never had an incident during its history of operation that would be considered an emergency action level.

Commercial Nuclear Power Reactors

There are two commercial nuclear power reactors which could have an impact on the health and safety of Missouri citizens. These reactors are the Callaway Nuclear Plant and the Cooper Nuclear Station. Both of the plants are used for electrical power generation. Both utilities have Emergency Plans that conform to NUREG-0654, FEMA-REP-1 Rev.1, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants. The utilities and the state are required annually to demonstrate various elements of preparedness in their plans through radiological emergency drills evaluated by inspectors representing the Federal Emergency Management Agency (FEMA) and the NRC.

Callaway Nuclear Plant

The Callaway Plant consists of one unit with a pressurized water reactor capable of providing 1150 MW of electricity. The plant is located in Callaway County, Missouri and is owned and operated by Union Electric, St. Louis. It is located ten miles southwest of Fulton, 25 miles northeast of Jefferson City, 5 miles north of the Missouri River, and 80 miles west of St. Louis. The population within the 2.5-mile radius of the plant is low (approximately 30 residents). The 10-mile radius would include approximately 4,500 people. Taking into account political as well as physical boundaries, the 10-mile radius has been adjusted to include the City of Fulton (population 10,000). Thus, the population within the Plume Exposure Pathway is approximately 16,000. The plant site consists of 7,200 acres of land at the site, 6,800 of which are administered by the Missouri Department of Conservation as the Reform Conservation Area. Under this program, part of the area continues to be farmed, with income from farming providing funds for wildlife management and public recreation activities. Land within a 5-mile radius of the plant site is rural, consisting of 60 percent forest, 20 percent farm/crop land, and 20 percent pasture. **The Callaway Plant has declared eight Unusual Events since it came on line in 1984. To date the last declared event was on May 18, 1989.**

Cooper Nuclear Station

The Cooper Nuclear Station is a direct cycle boiling water type reactor with a net electrical generating capacity of 800,000 Kilowatts. The facility is owned and operated by the Nebraska Public Power District of Lincoln, Nebraska. The plant is located on the Nebraska side of the Missouri River, approximately 7 miles southwest of Rock Port, Missouri in Brownville, Nebraska. The Emergency Planning Zone within the Missouri side of the river is predominantly rural land, with the exception of the towns of Rock Port, population 1,511, Phelps City, population 39, Langdon, population 32, and Watson, population 117. Atchison County is primarily affected by the EPZ and is intersected by several major highways. Highways included are I-29, U.S. Highway 136, U.S. Highway 275, and Missouri Highway 111. The total population at risk in Atchison County, should there be a radiological incident, is: within 2 miles, approximately 15 people; within five miles, approximately 246 people; and within ten miles, approximately 2,660 people. **The Cooper Nuclear Station has declared 22 Unusual Events since 1974 when it began operation. To date the last declared event occurred on November 19, 1996.**

IV. MEASURE OF PROBABILITY AND SEVERITY

The consequences of a radiological incident originating from one of the commercial nuclear power plants affecting the state can range in severity from insignificant to a high degree of radioactive contamination within the 2-10 mile area surrounding the facility. The most crucial concerns during a severe incident would be the safe evacuation of the public and controlled access to the areas affected by a release of radioactive materials. In the aftermath, the main concerns are: the extent of property needed to be decontaminated; identifying any contaminated food sources; and the amount of time it would take to reach acceptable exposure rates to allow safe reentry of the public. Historically, due to their safe operation records, there is no indication that any of the fixed nuclear facilities affecting the state represent a high risk. **The Reactor Safety Study conducted by the NRC rated the chances of a major nuclear disaster related to a power plant as very low (a probability of one in one million per plant operating year).** The report concluded that the worst accident type that could affect a nuclear power plant would be one resulting in a meltdown which could be expected to occur once in 20,000 years of reactor operation. The report also stated that a meltdown would likely cause less than one fatality or injury. **This low hazard rating is due to all of the added safety engineered instrumentation used to monitor and shut down nuclear plant systems prior to any severe damage occurring.**

V. IMPACT OF THE HAZARD

An incident at a nuclear power plant resulting in a General Emergency and evacuation (one where a release from the site boundary would be expected) could have a dramatic psychological impact on the uninformed population within the evacuation zone. The utilities and the State of Missouri have an active Radiological Emergency Preparedness program to prepare local jurisdictions and the general population surrounding the plant for responding to such an incident. This program includes in-depth training of resources both from the state and local jurisdictions, and regularly scheduled drills and exercises which are evaluated by the Federal Emergency Management Agency. Extensive planning has been given to implementation of the emergency response plan for both the state and local jurisdictions. Emphasis is placed on prompt notification of emergency organizations and the public; evacuation routes; reception and care centers for evacuees; monitoring for radiological contamination; emergency worker preparedness; and public information in the form of brochures distributed to residents within the Emergency Preparedness Zone. These programs are essential to the protection of the general public.

VI. SYNOPSIS

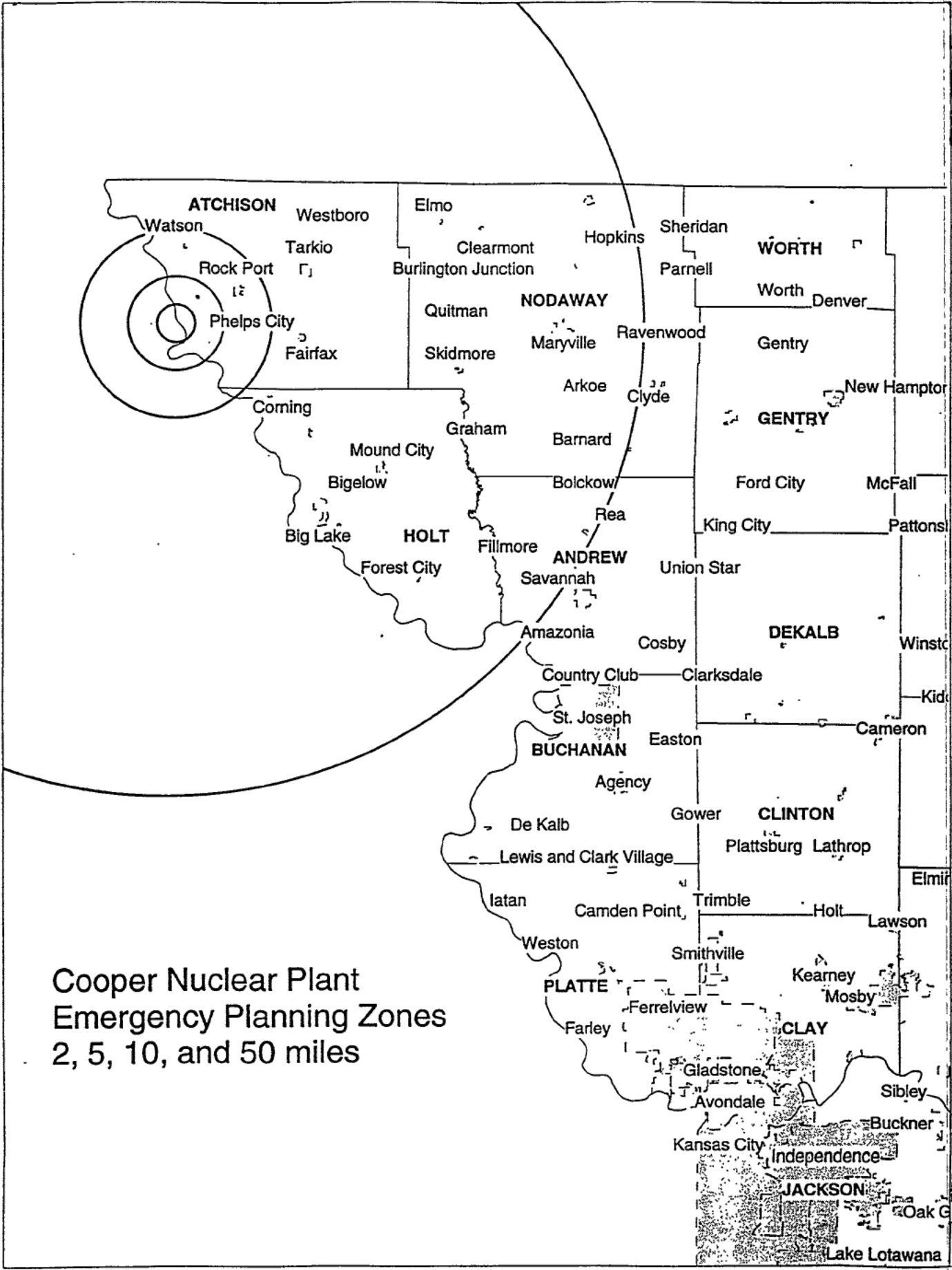
Nuclear reactors in the U.S. have been designed to survive natural disasters such as tornadoes and earthquakes without damage to critical systems. Considerable emphasis is placed on multiple-level governmental reviews of the design, construction and operation of each nuclear power plant. These safety reviews begin prior to construction and continue throughout the operating life of the plant. Radiological Planning and Preparedness programs that are monitored by state and federal agencies are in place to ensure that the safety of the general public is a priority within the Emergency Planning Zone. In addition, nuclear power plant history in the state and on a national level give no indication that a serious accident involving a nuclear power plant will ever occur.

VII. MAPS OR OTHER ATTACHMENTS

Attachment 1 - EPZ map of Callaway Nuclear Power Plant (page J-6)

Attachment 2 - EPZ map of Cooper County Nuclear Plant (page J-7)





Cooper Nuclear Plant
Emergency Planning Zones
2, 5, 10, and 50 miles

HAZARDOUS MATERIALS; OTHER ENVIRONMENTAL ISSUES

I. TYPE OF HAZARD

Hazardous Materials; Other Environmental Issues

II. DESCRIPTION OF HAZARD

A hazardous material is any substance or material in a quantity or form that may pose a reasonable risk to health, the environment or property. Incidents involving these substances, such as toxic chemicals, fuels, nuclear waste, and other radiological materials, for example, are covered in one principal category of Hazardous Materials. A second category, Other Environmental Issues, covers hazardous events which pose an adverse impact to air and/or water through the release of pollutants, by natural or man-caused means. These are noted in Section VI (Synopsis) of this annex.

With hazardous materials, we need to consider two different kinds of incidents i.e., fixed facility and transportation accidents. With a fixed facility, the hazards are pre-identified and the facility is required by law to have risk management planning done and provide a copy of this plan to the Local Emergency Planning Commission (LEPC), and local fire departments. They must also fill out a Missouri Tier II form and file it with the Missouri Emergency Response Commission (MERC) in the State Emergency Management Agency (SEMA). A list of all facilities that filed a Tier II form is on file with SEMA, Hazardous Materials Program Manager. For specific site plans, each county LEPC by law is required to maintain a copy of these plans.

The exact location of a hazardous material accident is not possible to predict. The close proximity of railroad, highway, waterway and industry to densely populated areas, schools and businesses could put a large number of residents in danger. In addition, essential service facilities such as police and fire stations, hospitals, nursing homes and schools that are in proximity to major highway or railroads are also in jeopardy from a hazardous material incident.

Federal Highway Administration statistics indicate that one out of ten motor vehicles is engaged in the transportation of hazardous materials. The Corps of Engineers indicates that over 9,000 tons of petroleum products and over 200,000 tons of chemicals and related products are shipped by way of the Missouri River between Omaha and Kansas City by river barge.

Nationwide, over four billion tons of hazardous materials are shipped each year by various transportation modes. There are no less than 20 flights each day out of Lambert Airport carrying nuclear medicines, and Tri-State Motor Transit Company of Joplin has over 25 shipments of high explosives each week.

Missouri becomes even more involved because of its highway system and geographical location. With Interstate highways such as I-29, I-35, I-44, I-55 and I-70, Missouri offers the best road routes for commercial carriers traversing the continent. Even arterial United States highways in Missouri, such as U.S. 71, 13, 63, 54, etc., are maintained to such high standards as to provide more favorable traveling conditions than are found in other central states. Also, the locations of nuclear facilities in relation to mines and fuel processing plants cause shipments of radioactive products and wastes to cross Missouri.

Missouri will be at the crossroads for rail and trucking nuclear waste transportation to the Yucca Mountain, Nevada test site.

Truck shipments alone will affect 25 different states, 266 counties and two Indian Reservations. This will be a potentially large waste shipping campaign from as many as 19 nuclear reactors through corridor states to Nevada.

The railroads in Missouri transport voluminous amounts and kinds of materials on their 6,351 miles of rails that transverse the state. Though individual cars may be placarded to reveal contents such as hazardous materials, only estimates can be obtained concerning volumes of such materials because just interstate traffic can be counted or measured. Interstate shipments are accounted for only when they originate or terminate.

Increased use and movement of materials across the country has created serious problems for emergency services personnel. There are many factors which can transfer a simple transportation accident into an incident of potential hazard to high numbers of people. Following is a potpourri of such factors:

- There are over 14,000 different chemicals being shipped by various transportation modes.
- Some types of highly toxic chemicals do not require placarding if shipped in quantities of less than 1,000 pounds even though 900 pounds could wipe out a small town.
- Few emergency response organizations (state, city, or county) have any training for handling peacetime radiological problems, and none have adequate training.
- Lack of intelligence reports regarding activity of possible terrorists.

Other scenarios involve nuclear terrorism and faulty re-entry of nuclear powered satellites reaching the earth (such as COSMOS 954 in 1978 and SKYLAB in 1980). However, all other things considered, transportation of radioactive materials presents the most probable scenario for a radiological incident.

The Department of Energy has begun shipping by train about twenty-one million cubic feet of low specific activity (LSA) radioactive waste from the decommissioned Fernald site near Cincinnati, Ohio to a repository near Salt Lake City, Utah. The trains will be composed of forty-three (43) gondola cars each, with a frequency of about one (1) every nine (9) days for five (5) years.

These trains cross Missouri through St. Louis and Kansas City on the Union Pacific tracks (about the same route used by the Three Mile Island trains). They will be easy for SEMA to monitor, if desired, since the UP tracks run about five hundred (500) yards south of the SEMA headquarters building.

Eventually, the federal government will overcome all political barriers and finalize development of long-term repositories for spent fuel and other high-level radioactive wastes, and for transuranics (known as TRUwaste); probably at Yucca Mountain, Nevada and Carlsbad, New Mexico, respectively. When those shipments begin, speculations suggest numbers as high as thirty-six hundred (3600) shipments per year depending upon several variables.

Dispensing with speculation, we can look at factual numbers obtained from three (3) corporations in Missouri, Mallinckrodt Medical in Maryland Heights (St. Louis County), Tri-State Motor Transit in Joplin, and ABB-Combustion Engineering in Hematite (Jefferson County).

Mallinckrodt Medical is one of the largest manufacturer of radiopharmaceuticals in the world and average of forty-five hundred (4500) packages per week, 2000 to 2500 by air.

Tri-State is one of the largest single private carrier of radioactive materials in the world. In 1994, they carried no less than one hundred sixty-seven (167) shipments through Missouri.

ABB-Combustion Engineering operates a nuclear fuel fabrication facility in Jefferson County about seven (7) miles west of Festus/Crystal City. They receive about twenty (20) shipments of uranium hexafluoride (UF_6), a mildly radioactive but highly corrosive form of uranium. ABB-CE processes this material into ceramic pellet assemble fuel bundles for nuclear power reactors. They ship out about five hundred (500) assemblies, or about forty (40) truck loads per year.

Missouri truly is a hub of transportation. The Interstate corridors of I-44, I-70 and I-55 are the most commonly used for truck transport. U.S. Highway 36 crosses the northern counties while U.S. 60 crosses the southern counties. U.S. Highways 71, 13, 65 and 63 are well-traveled North-South arterials.

Although there are many railroads crossing Missouri at all points of the compass, the Union Pacific route between St. Louis and Kansas City is the most used for large radioactive material shipments. The switching yards at St. Louis and Kansas City process more transcontinental trains than any other yards.

During any radiological emergency, whether resulting from the detonation of a weapon or the misuse of industrial or medical radioisotopes, local officials and emergency responders will require support in the detection, monitoring and analysis of radiological data for decision-making.

This report is accompanied by maps showing the primary transportation corridors and the Emergency Planning Zones (EPZ) surrounding the two nuclear power plants affecting Missouri. The maps are color-coded to indicate relative degree of radiological risk.

In 1990, ATSDR (Agency for Toxic Substances and Disease Registry) began funding selected stated health departments to participate in the Hazardous Substances Emergency Events Surveillance (HSEES) system. Five states were initially funded. Missouri was added in the fiscal year 1994 and became the twelfth participating state (Figure 1) Minnesota and Mississippi were added to the HSEES system in fiscal year 1995. The goal of this surveillance project is to reduce injuries and deaths to first responders, employees and the general public from hazardous substance emergencies.

A hazardous substance release is entered into the HSEES system if it meets the following criteria:

1. An uncontrolled or illegal release or threatened release of one or more hazardous substances;
2. The substances that are actually released or threatened to be released include **ALL** hazardous substances except petroleum products; and
3. The quantity of the hazardous substances which are released, or are threatened to be released, need (or would need) to be removed, cleaned up, or neutralized according to federal, state or local law; or
4. Only a threatened release of hazardous substances exists, but this threat leads to an action, such as an evacuation that can potentially impact on the health of employees, responders or the general public. This action makes the event eligible for inclusion into the surveillance system even though the hazardous substances are not released.

Data collection for the Missouri HSEES system began October 1, 1993. Reports of hazardous substances releases in Missouri come from a variety of sources, including the Missouri Department of Natural Resources (MDNR), the Missouri State Highway Patrol, Missouri Division of Fire Safety, Missouri Occupational Fatality Assessment & Control Evaluation (MOFACE) program, State Emergency Management Agency and media reports. The MDNR's Environmental Services Program is the primary notification source for Missouri's HSEES program.

Based on these reports, the HSEES coordinator contacts company officials, police/fire department personnel, victims, etc., to obtain the maximum amount of information about the event. Then, an incident report form is completed. The form includes the following information:

1. Where and when the event occurred, including whether the event took place at a fixed facility or during the transportation of the substance;
2. Weather conditions, time of day and day of the week when the event occurred;
3. Substance(s) and quantity released or substance(s) threaten to be released;
4. Data related to possible exposure, such as proximity to residential areas; the primary use of nearby land (e.g., commercial, industrial, agricultural or residential); the number of people living within one-quarter, one-half and one mile of the event; and how many people were actually home when the release took place; and
5. Deaths and injuries that resulted from the event, including who was injured (e.g., employee, general public, responder), the number and severity of injuries and

steps that may have been taken to prevent deaths or injuries (e.g., type of personal protective equipment that the injured used, use of decontamination, evacuation and in-place sheltering).

III. HISTORICAL STATISTICS

The Missouri Department of Natural Resources Environmental Services Program maintains Environmental Emergency Response (EER) reports. All environmental emergencies are to be reported, 24 hours a day, to (314) 634-2436. A total of 1,694 reports were received beginning October 1, 1994 through September 30, 1995. Of these, 859 (51%) were petroleum related. There were 366 (22%) potential hazardous substances emergency events (Figure 2).

Beginning in January, 1995, the HSEES program started receiving faxed reports from the U.S. Coast Guard's National Response Center (NRC) on a daily basis. A total of 90 potential hazardous substance emergencies were reported for Missouri. Of these 90 reports, 62 (69%) met the HSEES case criteria and were entered in the HSEES database as events.

Out of the 734 events from all sources investigated by the HSEES Coordinator, 329 investigations were entered into the HSEES data base. Three hundred eighteen (318/97%) of these met the case definition. This represents a 65% increase over fiscal year '94 which had 193 events.

Types of releases reported were: spill, air emission, fire, explosion, threatened and other. Spills were the most common type of release followed by air emissions and combination releases that involved two or more types of release (i.e. spill and fire; fire and explosion; or fire and air emission) (Figure 3).

A total of 349 substances were released in the 318 events. The majority of events (292/92%) released only one substance. The highest number of substances released in any event was 4. The most commonly released substance was ammonia with 43 (13%) releases, followed by sulfuric acid, 19 (6%) releases, ethylene glycol, 18 (6%) releases, sodium hydroxide with 12 (4%) releases, lead and phosphoric acid with 9 (3%) releases and hydrochloric acid with 8 (2%) releases (Figures 4 and 5).

Events occurred throughout the state, in 61 counties and the City of St. Louis. This represents slightly over 50% of the counties of the state. Events occurred primarily in counties where there are larger cities, interstate highways and large manufacturing or mining facilities. Figure 6 and Table 1 show the number of events occurring in each county. One hundred seventy (53%) of the releases occurred at fixed facilities. One hundred forty-eight events (47%) were transportation related. Of the 148 transportation-related events, 134 were ground transportation (e.g. truck, van, tractor, automobile); 10 were rail; 2 were pipeline; 1 was water; and 1 was an other (Figures 7 and 8).

In Missouri, 39 counties and the City of St. Louis have interstate highways running through them. Since the majority of transportation-related events (92%) involved ground transportation, we have taken a closer look at these events. Ground incidents occurred in 21 of the 40 counties (including the City of St. Louis) with interstate highways. Closer analysis of these incidents shows that only 13 (9%) events occurred on an interstate highway. Analysis of these events shows that 11 incidents involved leaking loads or trailers along side the highway and 2 incidents were accident related. In

contrast, 11 events occurred on U.S. highways, other than interstates; 15 events occurred on State highways; 5 events occurred on lettered blacktop highways; 5 events occurred on gravel roads; and 17 events occurred on city streets. Eight events occurred at the intersection of 2 roads. Of these 8 events, 6 occurred at the intersection of city streets, 1 occurred at a U.S. highway and a gravel road, and 1 at a state highway and a gravel road. Sixty (60) events occurred at transportation terminals (Figure 11).

Note: Because reports were received and included from the HMIS reporting system, the number of transportation-related cases entered in the Missouri HSEES system greatly increased in FY '95. This increase does not mean there were actually more incidents in FY '95 than FY '94, only that the HSEES system became aware of them during FY '95. This should result in more complete data in subsequent years. Figures 9 and 10 show the difference in events by type from FY '94 and FY '95.

Of all events, 271 (85%) occurred on weekdays. Forty-seven events (15%) occurred on the weekend. Slightly over half the events, 179 (56%), occurred between 6 a.m. and 6 p.m., with 136 (50%) occurring between the core working hours of 8 a.m. and 5 p.m., Monday-Friday. Forty-nine (15%) occurred between midnight and 6 a.m. and 45 (14%) occurred between 6 p.m. and midnight. Time of event was unknown for 38 (12%) events occurring on weekdays, and 7 (2%) events occurring on weekends (Figures 12 and 13).

Evacuations were ordered in 22 (7%) events (Figure 14). The number of people evacuated was known for 17 events and unknown for 5 events. From these 17 events, 2,161 people were evacuated. Of known people evacuated, the largest number was 400 and the smallest number was zero in any single evacuation. One event involved evacuating the affected area of the facility, but no one was working in the area. This area was kept off limits for two hours, before allowing any employees to enter. Sixteen of the evacuations involved the evacuation of affected building(s) or part of the building, 4 were circle/radius evacuations, one was a downwind evacuation and one had no criteria (Figure 15). A total of 27 substances were released in these 22 events. Figure 16 shows the most commonly released substances when an evacuation occurred.

Ammonia was the most commonly involved substance, occurring in 9 events with a total of 1,352 evacuees. One event had 2 forms of ammonia released, ammonium nitrate and ammonia phosphate. Acids and solvents were involved in 3 events each with a total of 700 evacuees. Lead was involved in 2 events with 100 evacuees and asbestos and oxidizers were involved in 2 events with an unknown number of people evacuated. An insecticide was involved in 1 incident and caused the evacuation of one person. Inorganics were involved in 2 events and resulted in the evacuation of 8 people.

Nine (3%) releases resulted in 13 injuries and 1 death. The largest number of injuries associated with a release was 2. The most common type of injury reported was respiratory irritation, which occurred in 6 (43%) of the victims. Other types of injuries/symptoms included eye irritation, chemical burns, thermal burns, skin irritation, dizziness/CNS, vomiting and trauma (Figures 17 and 18).

Of the 14 victims, one victim died, 6 were treated at the scene, 5 were transported to a hospital but not admitted, and 1 was admitted to a hospital. One person saw a private physician within 24 hours (Figure 19).

Employees were the largest group injured by releases. Twelve (12) employees were injured and 1 died. One responder was injured. No members of the general public were injured (Figure 20). Ammonia, lead, hydrogen sulfide and 1,3,5-trioxane were all involved with two injuries (14%). One release involved 3 substances, cleaning compound, phosphoric acid and sodium hydroxide. This release injured both an employee and a responder. The remaining 4 substances were involved with 1 injury, each (Figure 21).

IV. MEASURE OF PROBABILITY AND SEVERITY

HAZARDOUS MATERIALS TRANSPORTATION ACCIDENT

The probability of occurrence is rated as high because of the large volume of hazardous materials being hauled over the highways and railways. This rating means that the probability of occurrence is considered sufficiently high as to assume the event will occur at least once within the expected mode of transportation.

The severity of the consequences is rated as moderate, but may be either low or high depending on the location of the accident and the time of day. This rating means injuries and/or death are expected only for exposed personnel over extended periods of time or when individual personal health conditions create complications.

Note: The severity to the environment will be different in every case. It will depend upon the amount, type and method dispensed to determine the damage to property and the environment. Close coordination between the Missouri Department of Natural Resources, EPA, the local jurisdiction and the spiller will be required to insure that the environment is determined safe again.

HAZARDOUS MATERIALS FIXED FACILITY ACCIDENT:

The probability of occurrence is rated as moderate. With all of the new regulations from EPA and OSHA along with more stringent state laws and employee awareness training this rating may be lowered to low or raised to high by the county official for individual facilities based on past performances. This rating means the probability of occurrence is possible during the expected lifetime of the facility.

The severity of consequences is rated as moderate but may be either low or high depending on the type and amount of chemical released. This means the chemical is expected to move into the surrounding environment in concentration sufficient to cause serious injuries and/or death unless prompt and effective corrective actions is taken. Injuries and/or death expected only for personnel exposed over an extended period or when individual personal health conditions create complications.

Note: The severity to the environment will be different in every case. It will depend upon the amount, type and method dispensed to determine the damage to property and the environment.

Close coordination between the Missouri Department of Natural Resources, EPA, the local jurisdiction and the spiller will be required to insure that the environment is determined safe again.

V. IMPACT

The entire State of Missouri is susceptible to this type of hazard. Depending on a number of factors such as:

- Type of chemical
- Amount released/spilled
- Method of release
- Location of release
- Time of day
- Weather Conditions

This hazard could have a significant impact on the public, the environment or private property.

The impact of this type of disaster will be localized to the immediate area surrounding the incident. The initial concern will be to the people, then the environment. If there is contamination, then the spiller is responsible for the clean-up actions and will work closely with the Missouri Department of Natural Resources, the EPA and the local jurisdiction to ensure clean-up is done safely and in accordance with federal and state laws.

Local government, county and/or municipal, is more directly impacted by radiological incidents than state or federal government. Local responders are, invariably, the first on scene for any incident. Therefore, they have the responsibility to treat any injured on scene and transport them to a hospital for more complete medical care. Also, local first responders have the initial responsibility of controlling exposure of emergency workers and the public to any radioactive materials, and to contain the spread of radioactive contamination as much as possible. While clean-up of any actual spill of radioactive materials rests with the shipper (in most cases), local responders must provide site control for several hours until the responsible parties arrive on the scene.

A recent survey was completed of Missouri fire departments across the state asking their perception of their own capability to respond to a radiological incident. Out of four hundred thirty-three (433) departments surveyed, only one hundred eighteen (118) responded. Of those, twenty-one (21) believe they could adequately handle a radiological incident until proper authorities arrive.

It is clearly indicated that there are pockets of radiological response capability throughout the state. However, there are disturbing gaps in some of the main transportation corridors. It is also clear that training needs to be encouraged along these corridors. The same consideration must be given to any county located under commercial flyways or where it might be possible for a fallen satellite to leave a contaminated "footprint." (COSMOS 954 left a 200-mile footprint in the Northwest Territory of Canada in 1978).

VI. SYNOPSIS

Any disaster or emergency could result in additional concerns when it interacts with the presence of hazardous materials. A recent case in point was the Floods of '93, when large propane tanks in St. Louis were threatened by rising floodwaters, forcing evacuations of nearby residents in several areas. Each new emergency will need to be evaluated and top priority given first to the protection of the public, then the environment and property.

Other Environmental Issues

Although the State has never had an environmental disaster of large proportions, there are many instances where hazardous substances can impact the environment with considerable consequences to either air or water. Floods often temporarily interrupt community water supplies, creating the need for emergency potable water for thousands of people. In July '93, for example, St. Joseph City's municipal water plant was forced to shut down for an extended period when contaminated floodwater threatened to enter the system. Floodwaters also disrupt waste water treatment facilities, resulting in the discharge of raw or improperly treated sewage. Periodically, water pollutants cause fish kills in Missouri streams, and smog problems from air pollutants existing in large metropolitan areas.

Air Pollution: Air quality in Missouri is monitored by 139 stations throughout the state. These stations are maintained by the U.S. Environmental Protection Agency (EPA), and state and local authorities. These stations can be divided into three separate groups: the National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and Special Purpose Monitors (SPM). These monitors measure suspended particulate, ozone, carbon monoxide, sulphur dioxide, nitrogen dioxide and lead. The last item listed is a unique one. Missouri's lead industry produces about 90% of the new lead in the nation. The three large lead smelters in Missouri (near Herculaneum) have their own monitoring network operated by the company that runs the smelters. It should be noted that the State monitors the network to ensure proper function. All data is forwarded to EPA. The EPA maintains a list of facilities which release the most toxic chemicals per year. Missouri's list of ten top facilities for 1993 is shown in Figure 23 in Section VII of this annex.

Because of high amounts of ozone, carbon dioxide, and other vehicular pollutants in the St. Louis Metropolitan Area, vehicles registered in the counties of St. Louis, St. Charles and Jefferson, as well as St. Louis City, are required to have an emissions check of their exhaust systems. All service areas around St. Louis are now required to have new gas nozzles that recapture gasoline vapors, thus preventing them from being released to the atmosphere. These vapors (unburned hydrocarbons) chemically react with nitrogen oxides when exposed to the sunlight and form ozone, which is the basis for smog. For more information on the Air Pollution Control Program, contact the Missouri Department of Natural Resources at (573) 751-4817.

Water Pollution: The Missouri Department of Natural Resources also maintains the state's water quality management plan, and has individual plans for each drainage basin in Missouri. These are: Grand/Chariton Rivers Basin, Des Moines/Salt Rivers Basin, Osage/Gasconade River Basin, Meramec and small direct tributaries to the Mississippi Basin, and Missouri and small direct tributaries.

In all, 20,536 miles of Missouri waterway come under the provisions of the state's Clean Water Act. Of these waters, 50.6 percent (10,390.5 miles) meet clean water goals. The remaining 10,145.5 miles of water do not meet the clean water goals, but only 70.5 miles are considered serious water quality problems. Of the 10,145.5 miles of waterway not meeting the goals, it is estimated that 5,000 to 8,000 miles will probably never meet the goal of good aquatic habitat (fishable) because of natural conditions.

Types of Water Pollutants: The most recent available water quality report indicates the most important pollutants in Missouri are:

- Sediment deposited in streams from soil erosion.
- Acid mine drainage from abandoned coal mines (acidity, sulfate, iron, and coal solids).
- Municipal sewage treatment plant effluent (ammonia, fecal coliform, and suspended solids).
- Depositions of lead/zinc mine tailings (silt sized mineral particles).
- Releases from reservoirs (low dissolved oxygen, manganese, temperature changes, velocities).

The water quality report also states there are several other water quality concerns:

- Stream channelization, which causes degradation and even loss of aquatic habitat, increases in erosion/severity of flooding, increases of water temperature and reduction of oxygen level.
- Abandoned lead-zinc mining areas allow streams to increase sediments deposited and allow heavy metals to enter the food chain through dissolution.
- High-density residential and commercial development in areas around the Lake of the Ozarks has made it impractical to have centralized sewage collection and treatment
- Hazardous waste sites in Missouri deposit a plethora of chemicals into Missouri waterways. Until these sites are cleaned up, they will continue to be hazardous to people and wildlife.

Identifying Pollution Hazard Areas

Local emergency management officials should identify pollution hazard areas so that in case of a natural disaster, recovery steps will not be delayed. Pollution of public drinking water, for example, can cause severe problems with re-entry and recovery. If alternate sources of safe drinking water can be identified, or relocation of water intakes can eliminate polluted drinking water, then recovery can be that much quicker and local resources can be used to tackle other problems.

With the increases in motor vehicle registrations throughout the state, the levels of nitrocarbon emissions will naturally rise. Combinations of smog and carbon monoxide levels will also increase. These elements in sufficient quantities can have deleterious effects on the health of thousands of Missourians.

VII. MAPS OR OTHER ATTACHMENTS

Tier II Forms are filed and maintained by the Missouri Emergency Response Commission at SEMA. Site specific plans are on file with each County LEPC. Transportation and Evacuation Routes are identified in each County Emergency Operations Plan.

The 1995 Public Service Commission, Natural Gas Pipeline Map is on file with State Emergency Management Agency.

Attached are the HSEES Charts, Missouri Rail System, and EPA's Top Ten List of Facilities in Missouri Releasing Toxic Chemicals.

Table 1

**HSEES by Missouri County and Number of Events
October 1, 1994 - September 30, 1995**

Following is an alphabetical list of counties in which hazardous substances emergency event(s) occurred.

<u>COUNTY</u>	<u># OF EVENTS</u>	<u>COUNTY</u>	<u># OF EVENTS</u>
Adair	1	Lawrence	4
Audrain	2	Lewis	1
Barry	2	Marion	11
Bates	1	Mississippi	1
Boone	7	Monroe	1
Buchanan	4	Montgomery	2
Caldwell	1	New Madrid	1
Callaway	5	Newton	2
Cape Girardeau	4	Nodaway	1
Carroll	1	Osage	1
Cass	2	Pemiscot	2
Chariton	2	Perry	1
Christian	1	Pettis	2
Clay	8	Pike	5
Dallas	1	Platte	1
Dent	1	Polk	1
Franklin	4	Ralls	3
Gasconade	1	Saline	1
Greene	29	Scotland	1
Grundy	2	Scott	1
Harrison	1	Shelby	2
Henry	1	St. Charles	19
Holt	1	St. Francois	2
Howard	1	St. Louis City	20
Howell	1	St. Louis County	70
Iron	1	Ste. Genevieve	1
Jackson	37	Stoddard	1
Jasper	10	Taney	1
Jefferson	13	Texas	1
Johnson	6	Vernon	2
Lafayette	3	Webster	1

Figure 1

**STATES PARTICIPATING IN THE HAZARDOUS SUBSTANCES
EMERGENCY EVENTS SURVEILLANCE PROGRAM**

FY 1995

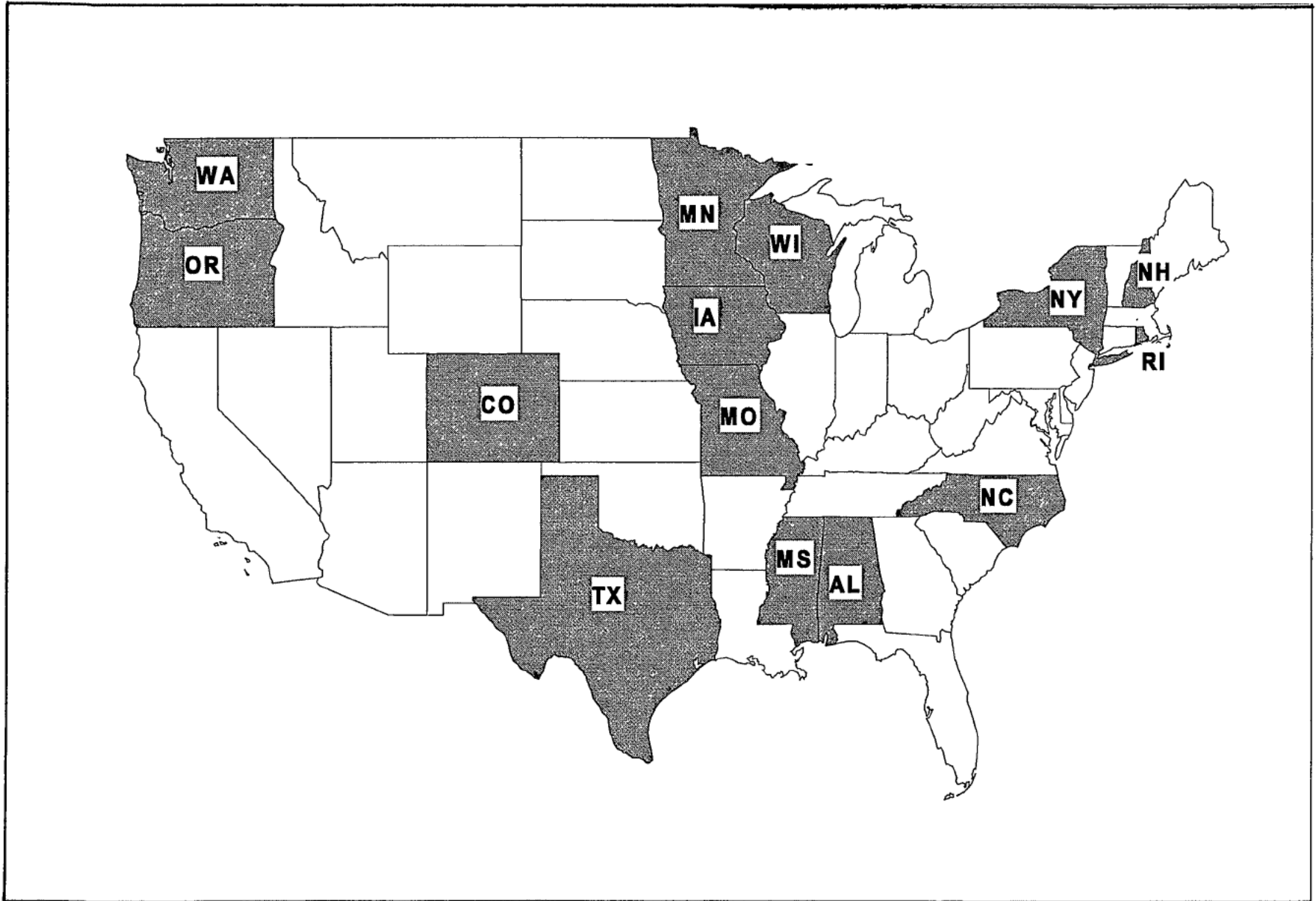
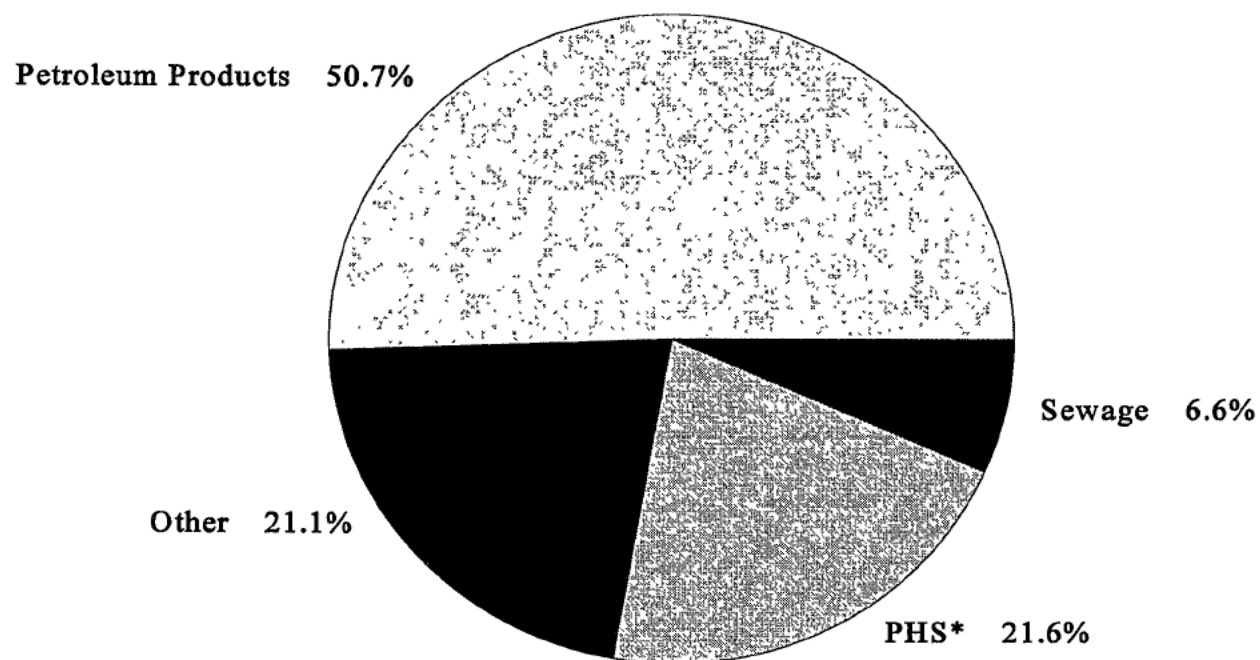


Figure 2

Environmental Emergency Response Reports Received by Missouri Department of Natural Resources by Type of Event

Oct. 1, 1994.- Sept. 30, 1995



***Potential Hazardous Substances**

Type of Release

MO HSEES

Oct. 1, 1994 - Sept. 30, 1995

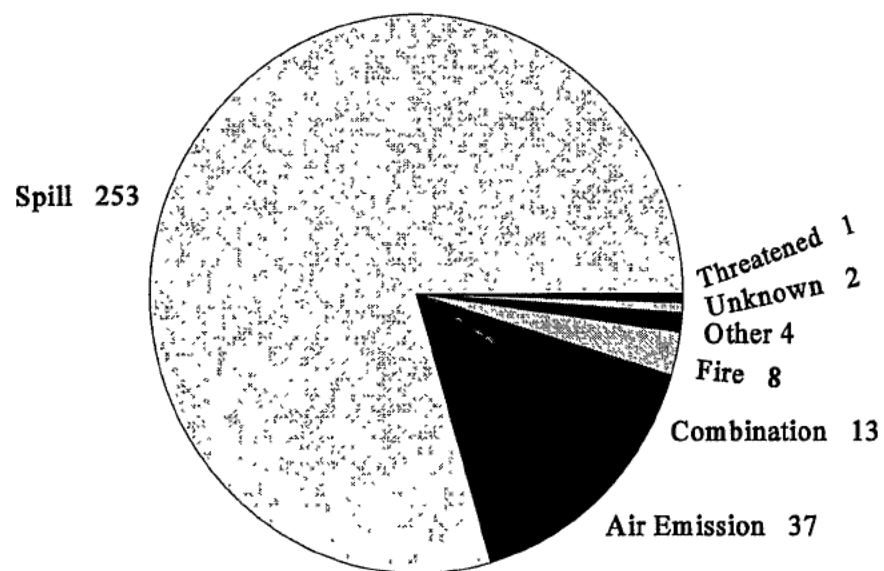


Figure 4

Number of Substances Released per Event

MO HSEES

Oct. 1, 1994 - Sept. 30, 1995

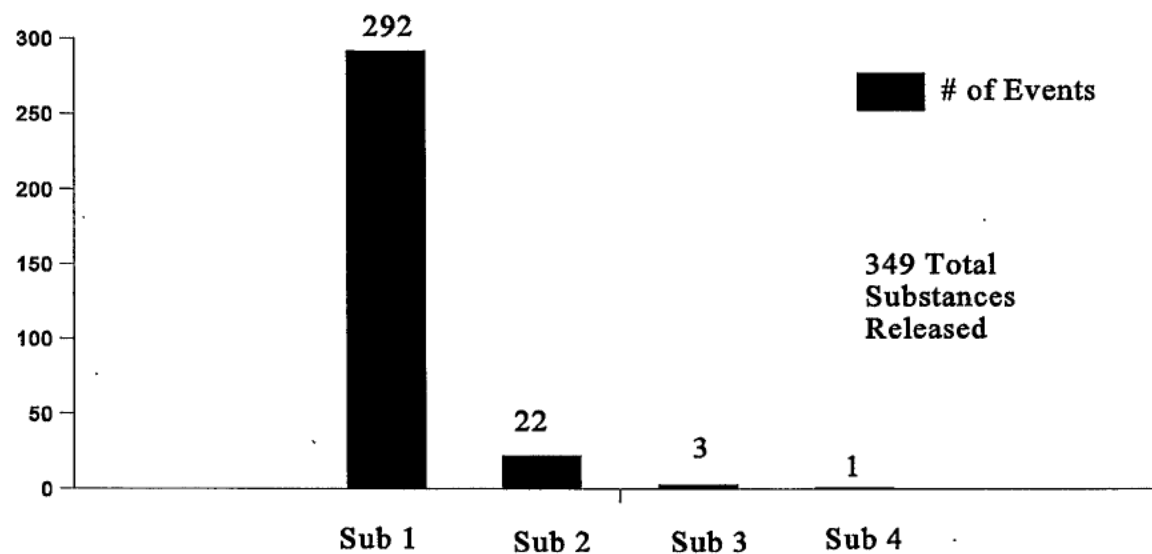


Figure 5

Most Frequently Released Substances

MO HSEES

Oct. 1, 1994 - Sept. 30, 1995

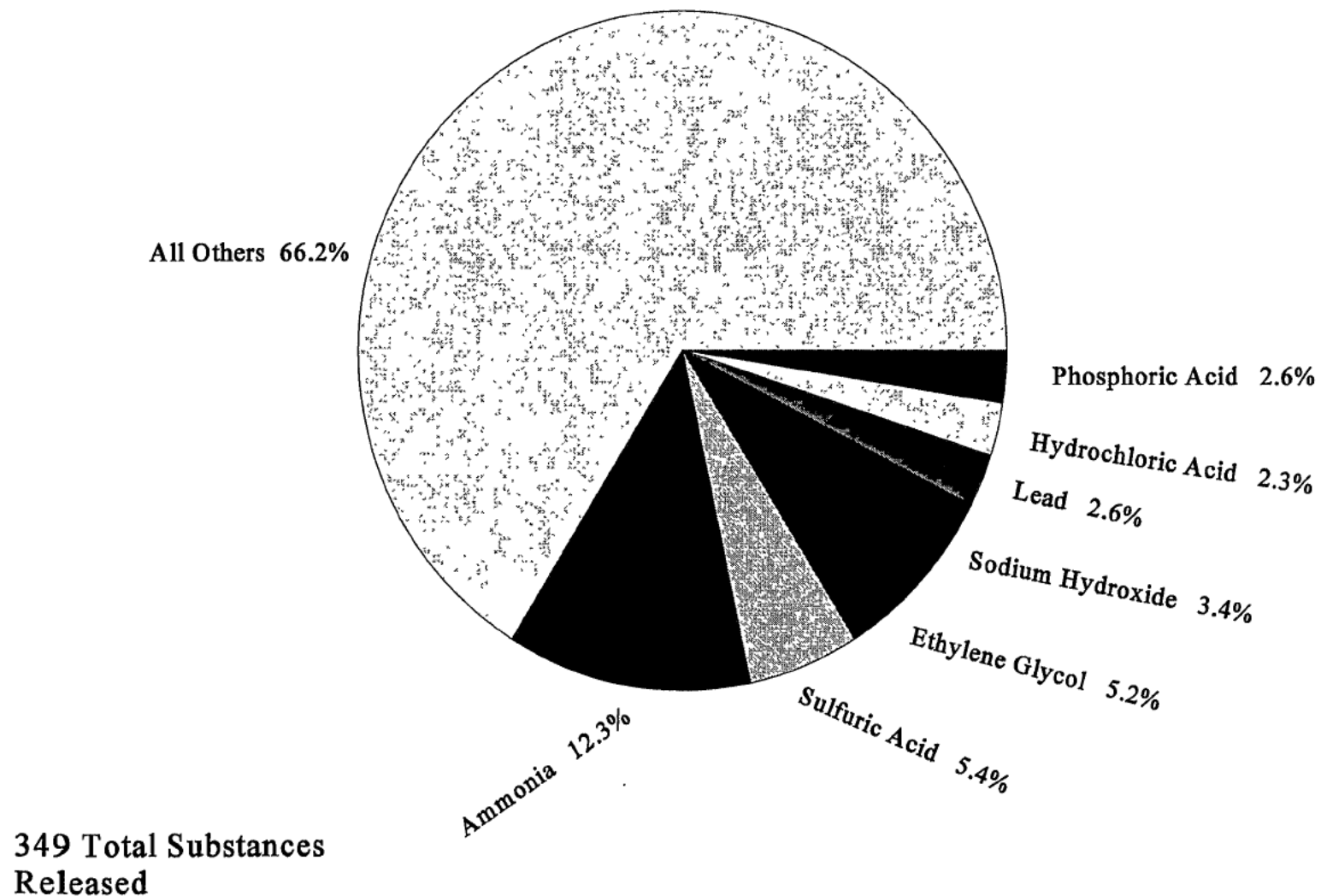


Figure 6

Missouri Department of Health Hazardous Substances Emergency Events Surveillance Hazardous Substances Emergency Events by County

October 1, 1994 - September 30, 1995

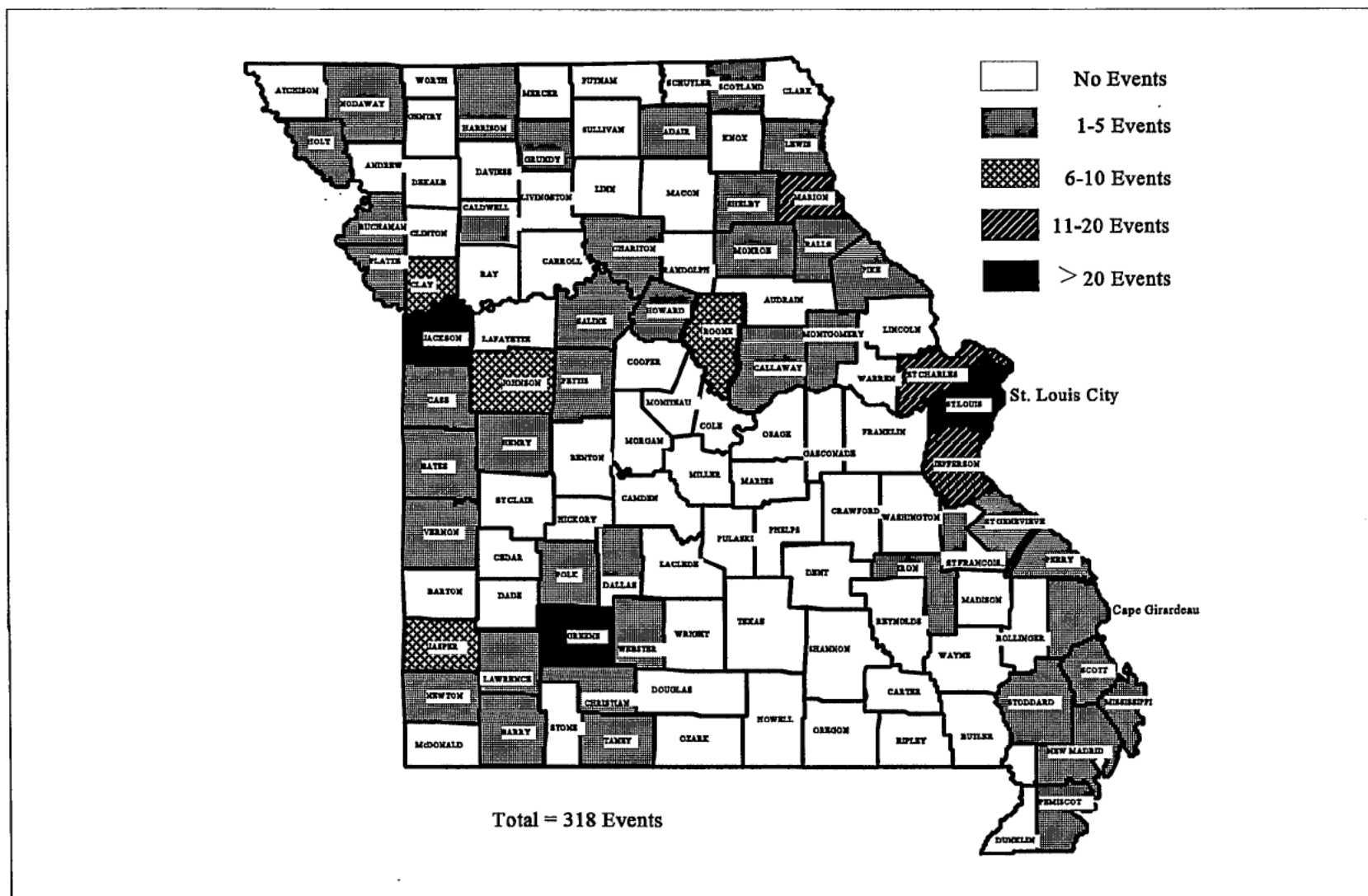


Figure 7

Events by Type & Type of Transportation

MO HSEES

Oct. 1, 1994 - Sept. 30, 1995

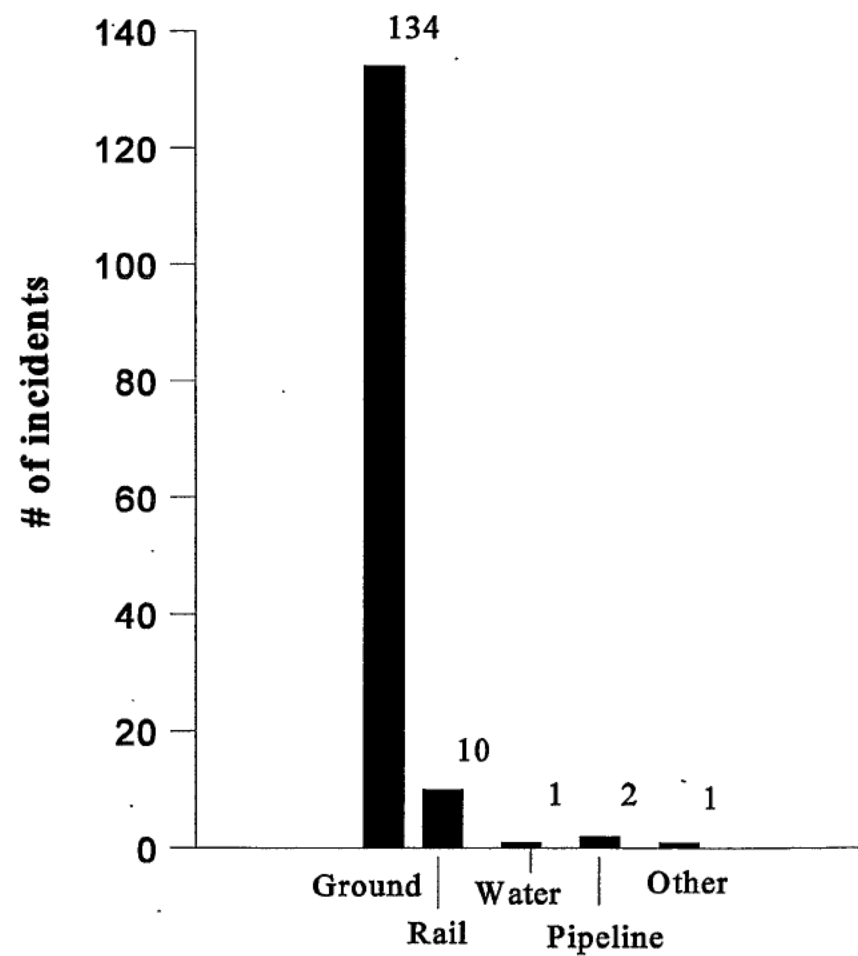
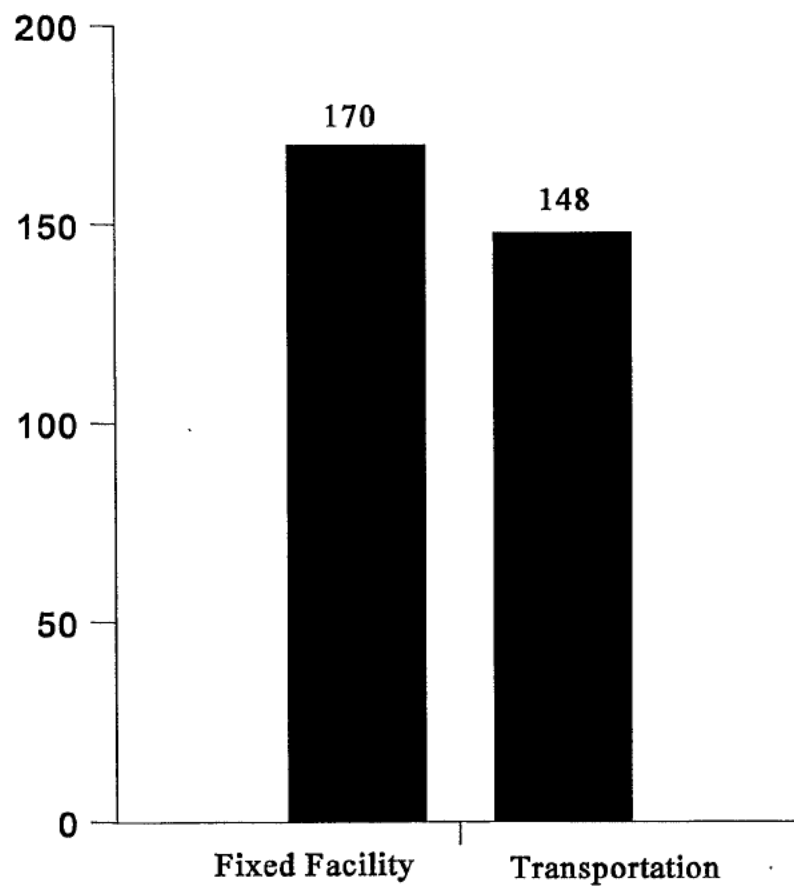
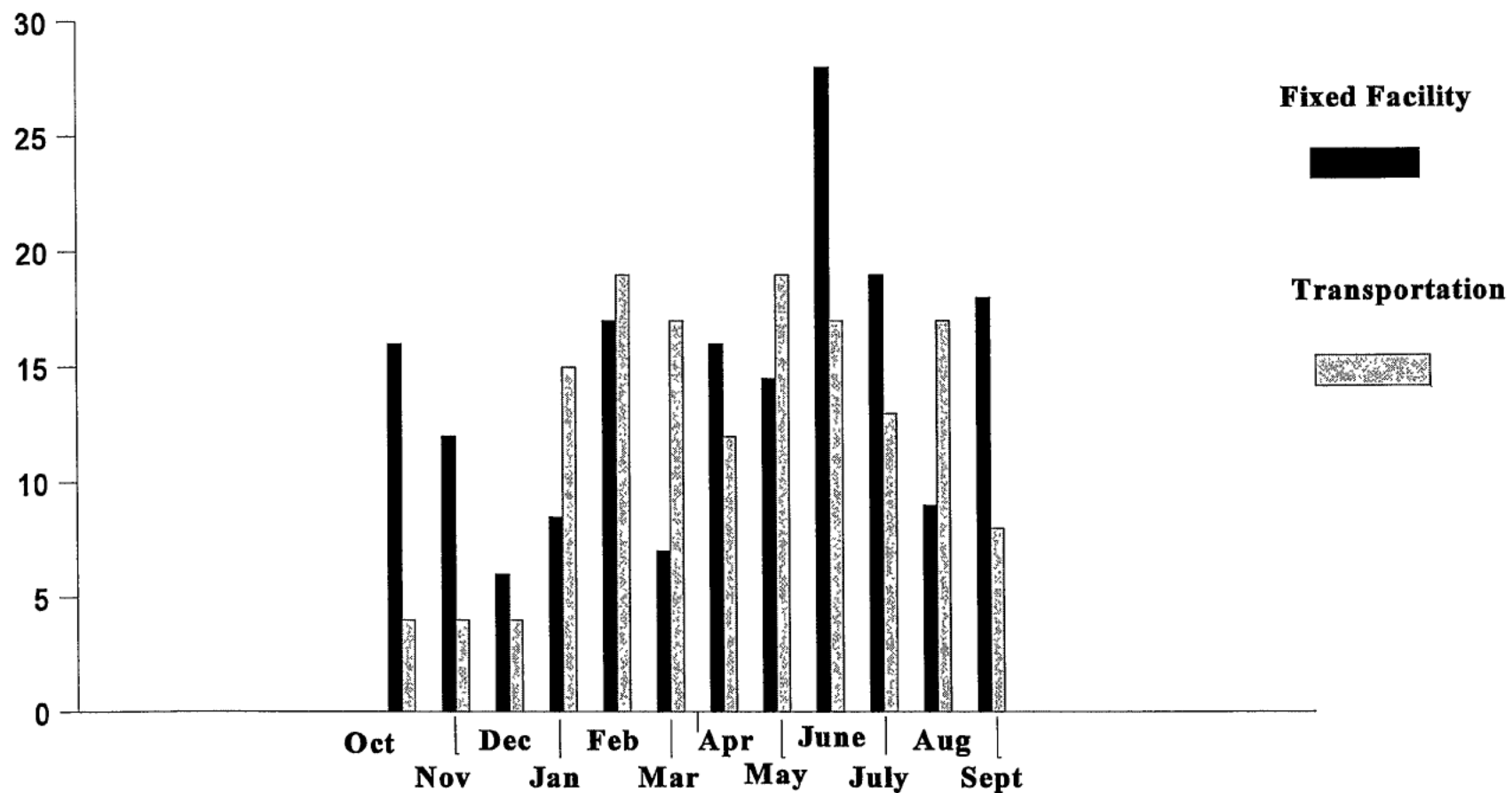


Figure 8

Event Type by Month

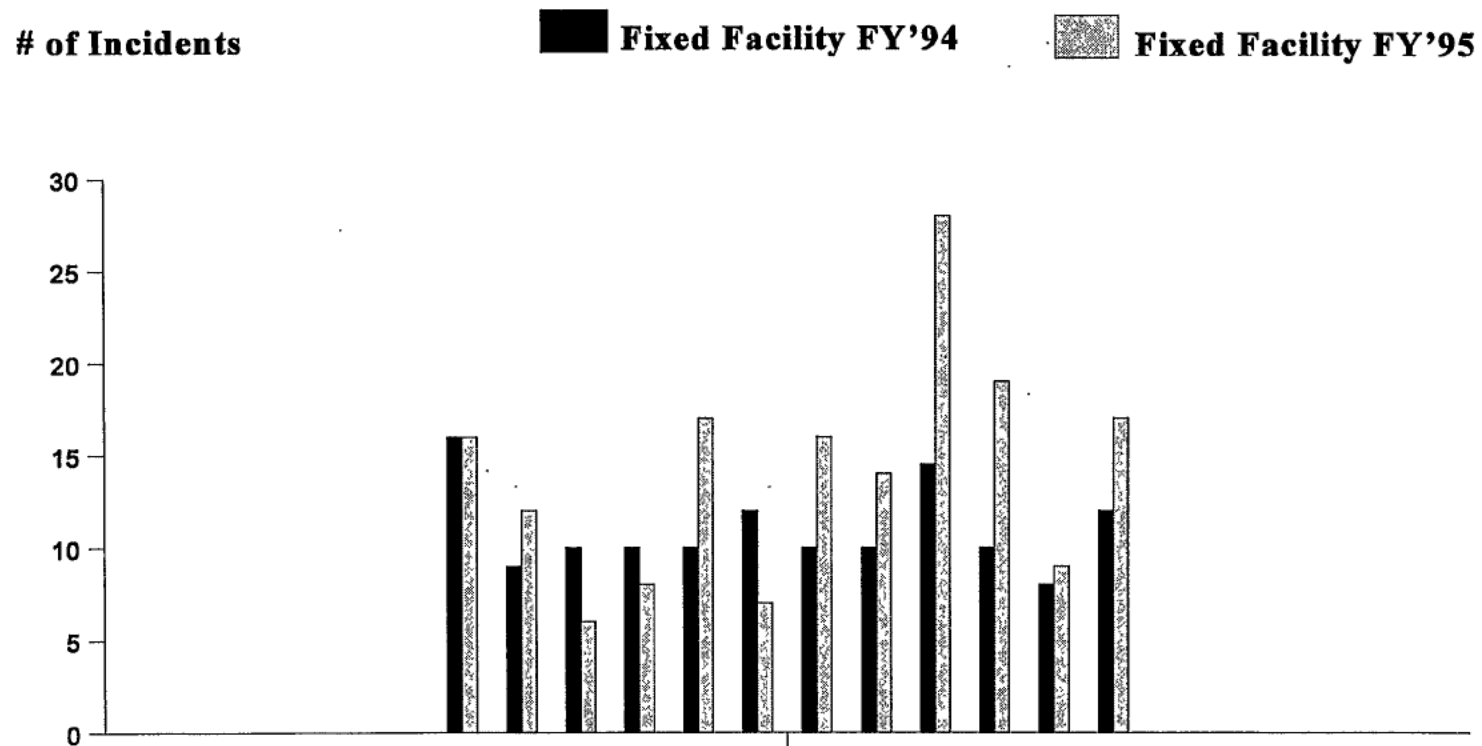
MO HSEES

Oct. 1, 1994 - Sept. 30, 1995



Event Type by Month & Year

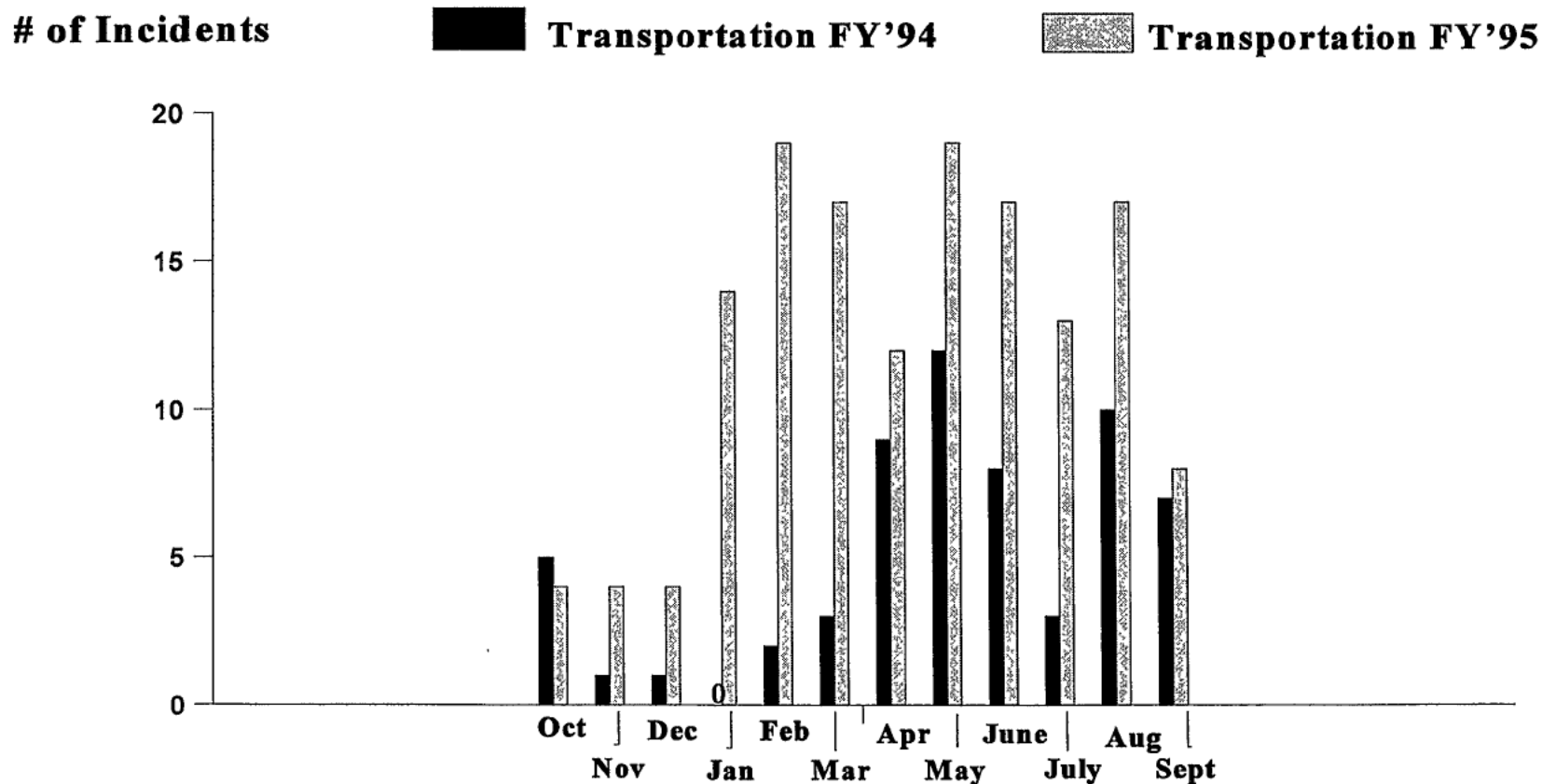
MO HSEES



Note: FY'95 data includes reports from Hazardous Materials Incident System (HMIS)

Event Type by Month & Year

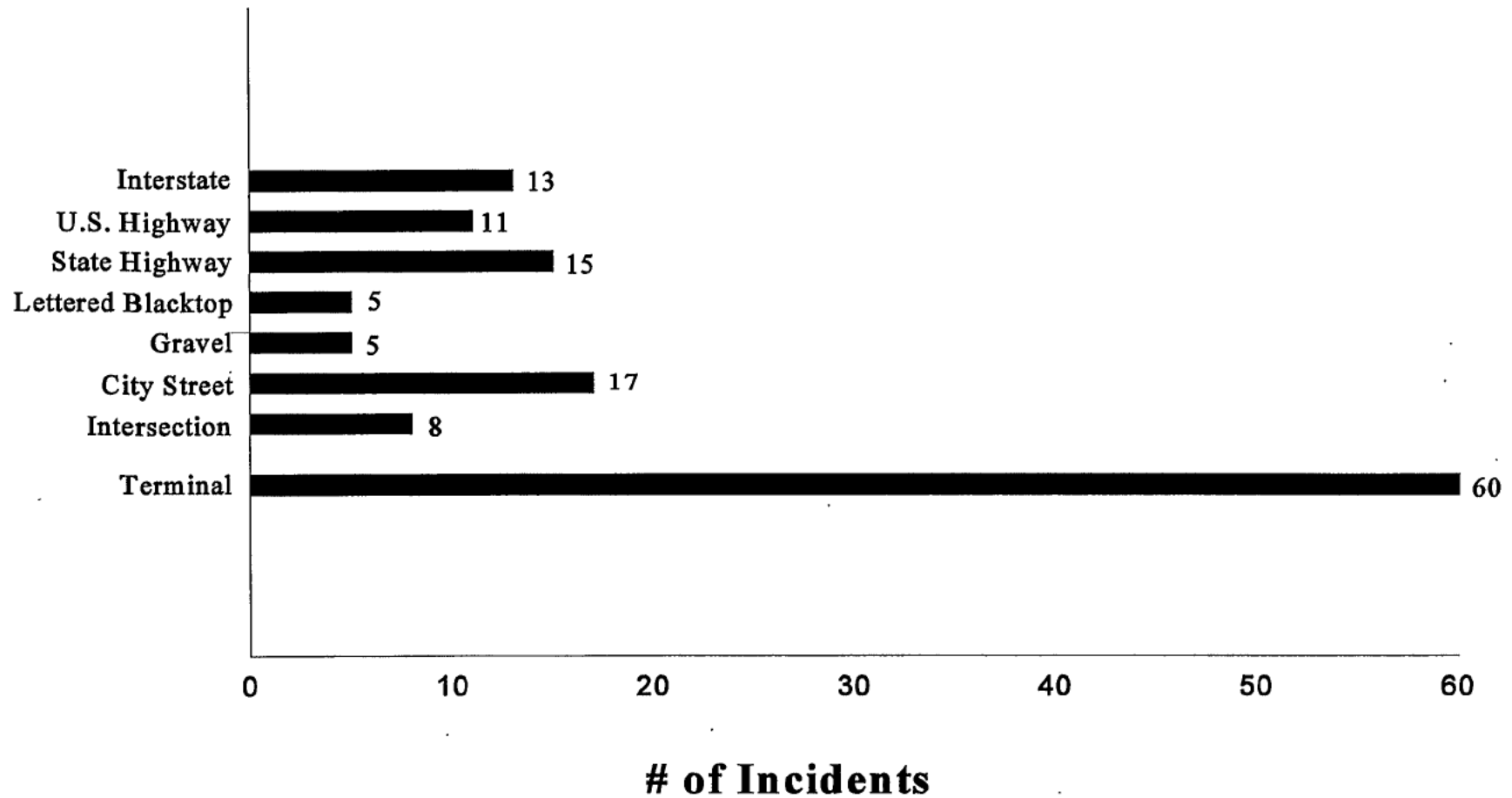
MO HSEES



Note: FY'95 data includes reports from Hazardous Materials Incident System (HMIS)

Ground Transportation Events by Location MO HSEES

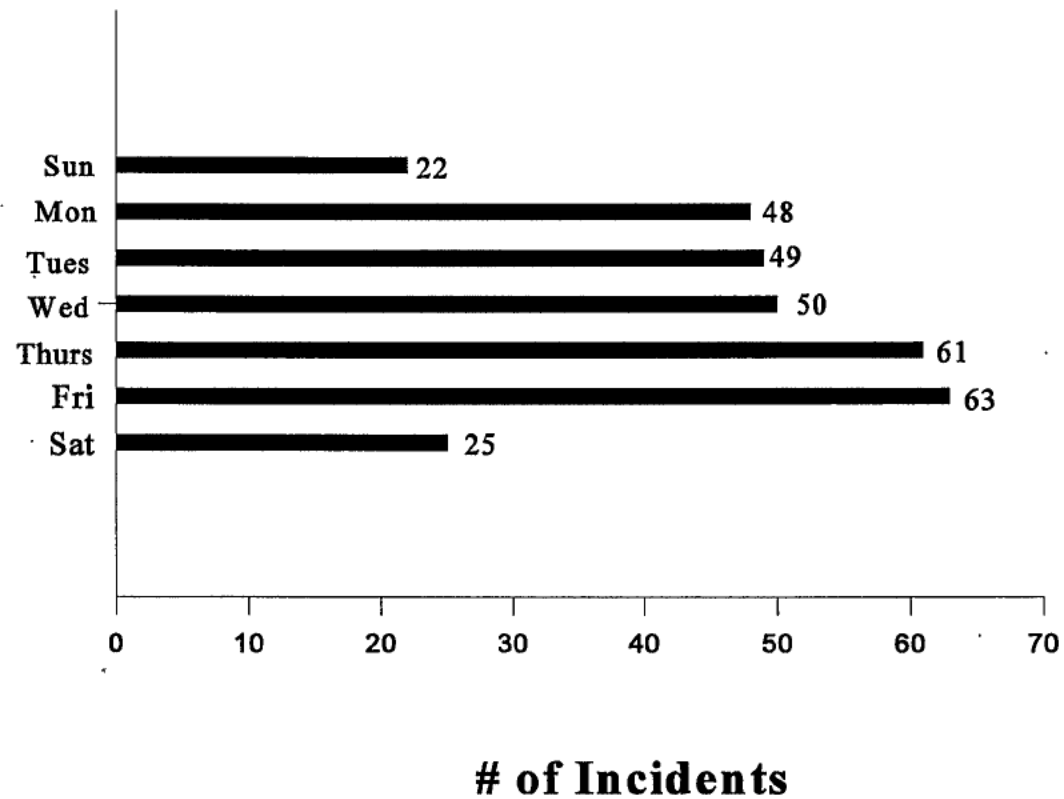
Oct. 1, 1994 - Sept. 30, 1995



Events by Day of the Week

MO HSEES

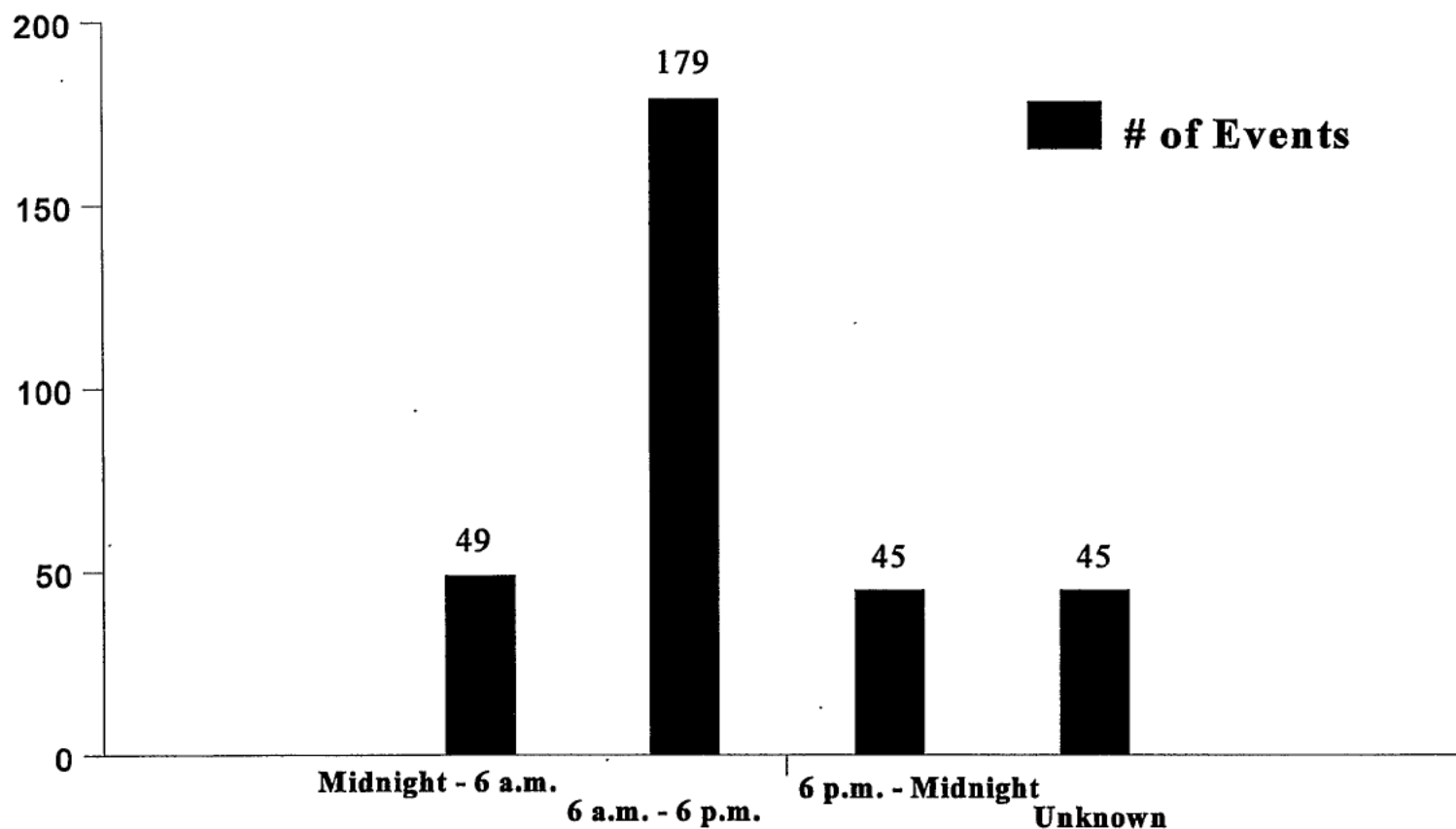
Oct. 1, 1994 - Sept. 30, 1995



Events by Time of Occurrence

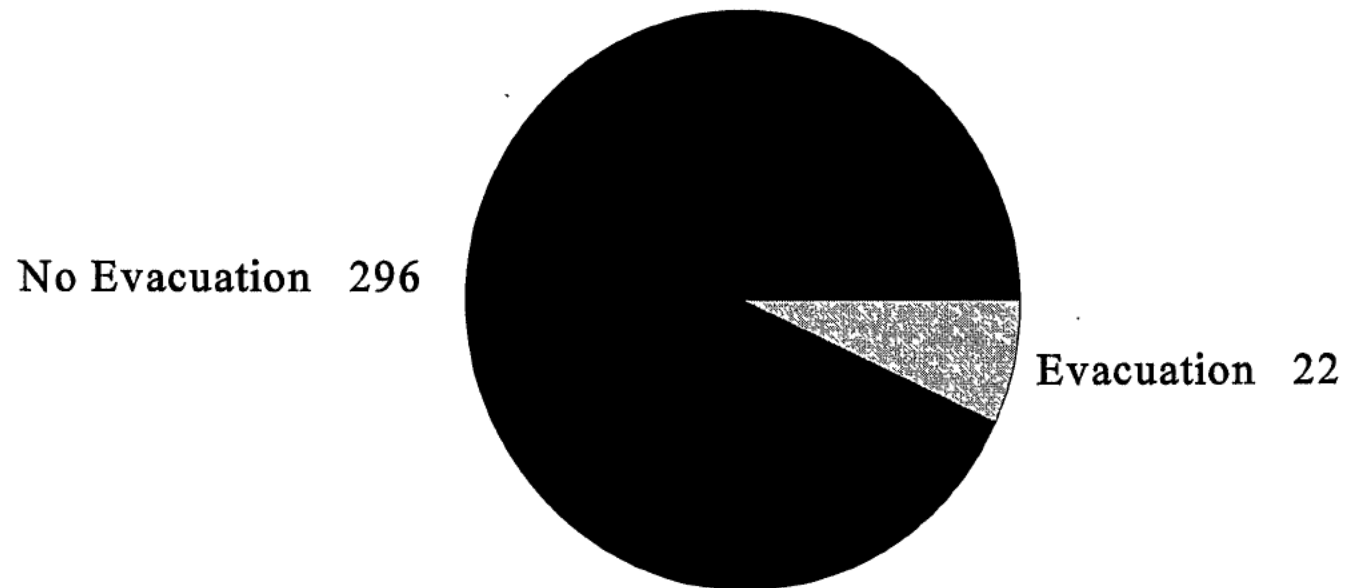
MO HSEES

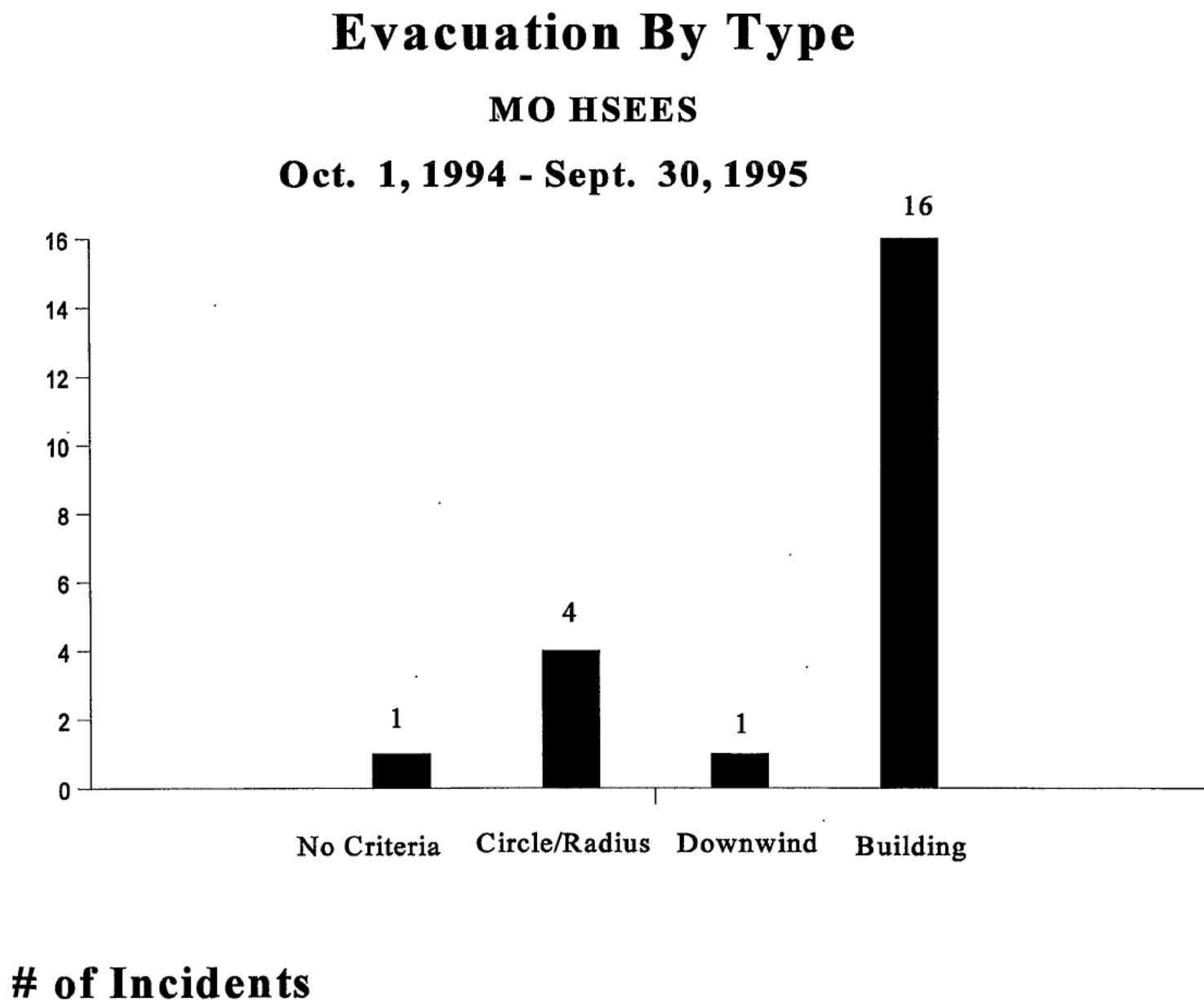
Oct. 1, 1994 - Sept. 30, 1995



Events Requiring Evacuation MO HSEES

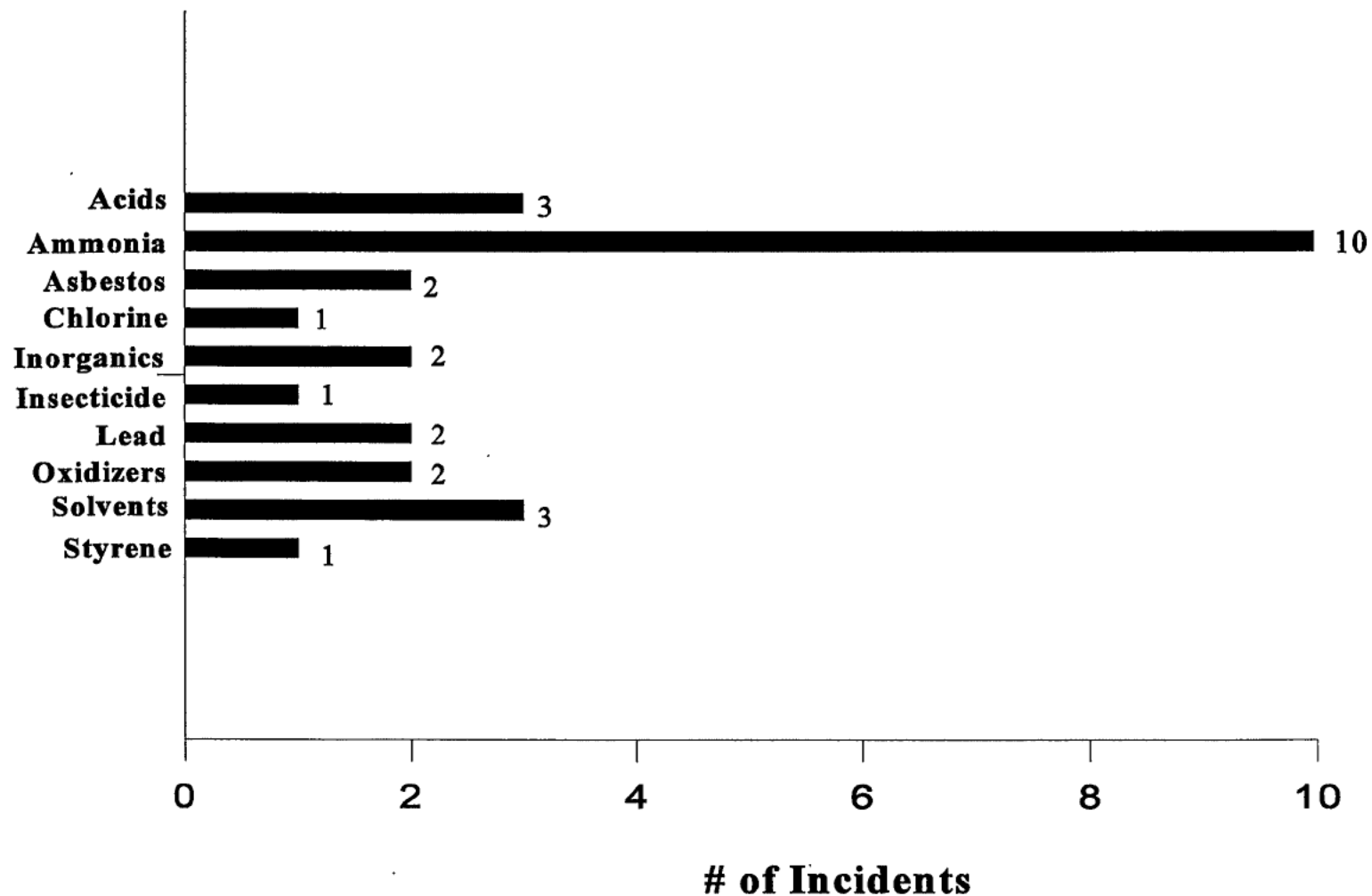
Oct. 1, 1994 - Sept. 30, 1995





Events Requiring Evacuation Most Commonly Released Substances MO HSEES

Oct. 1, 1994 - Sept. 30, 1995



Events with Injuries MO HSEES

Oct. 1, 1994 - Sept. 30, 1995

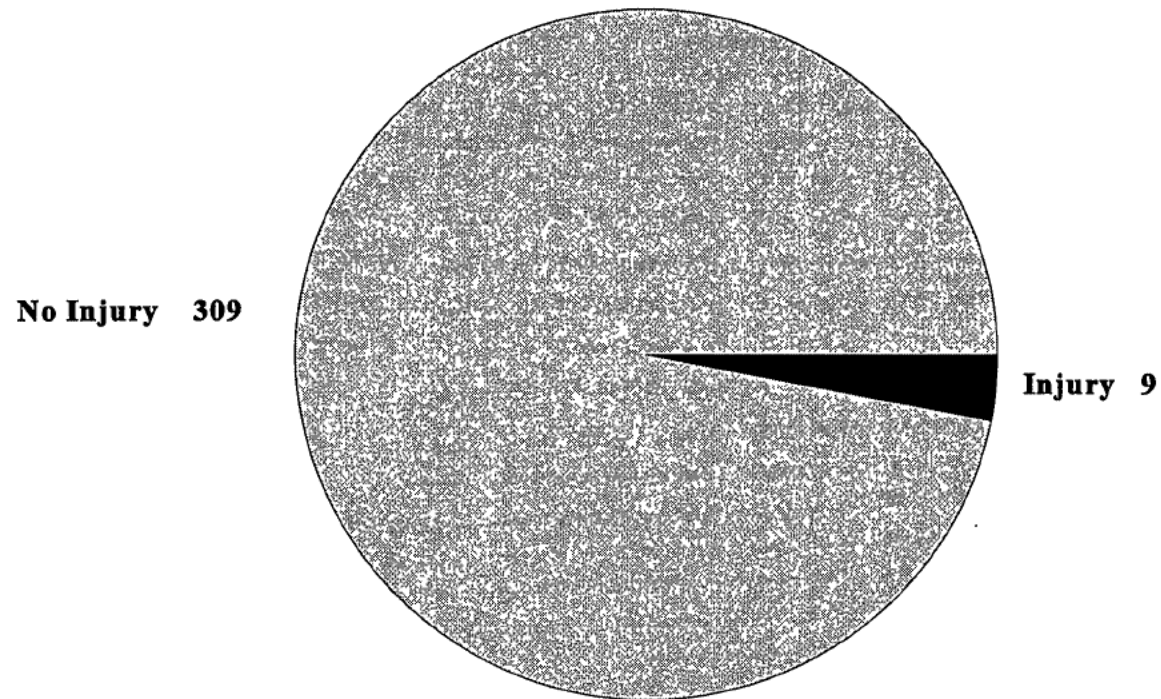
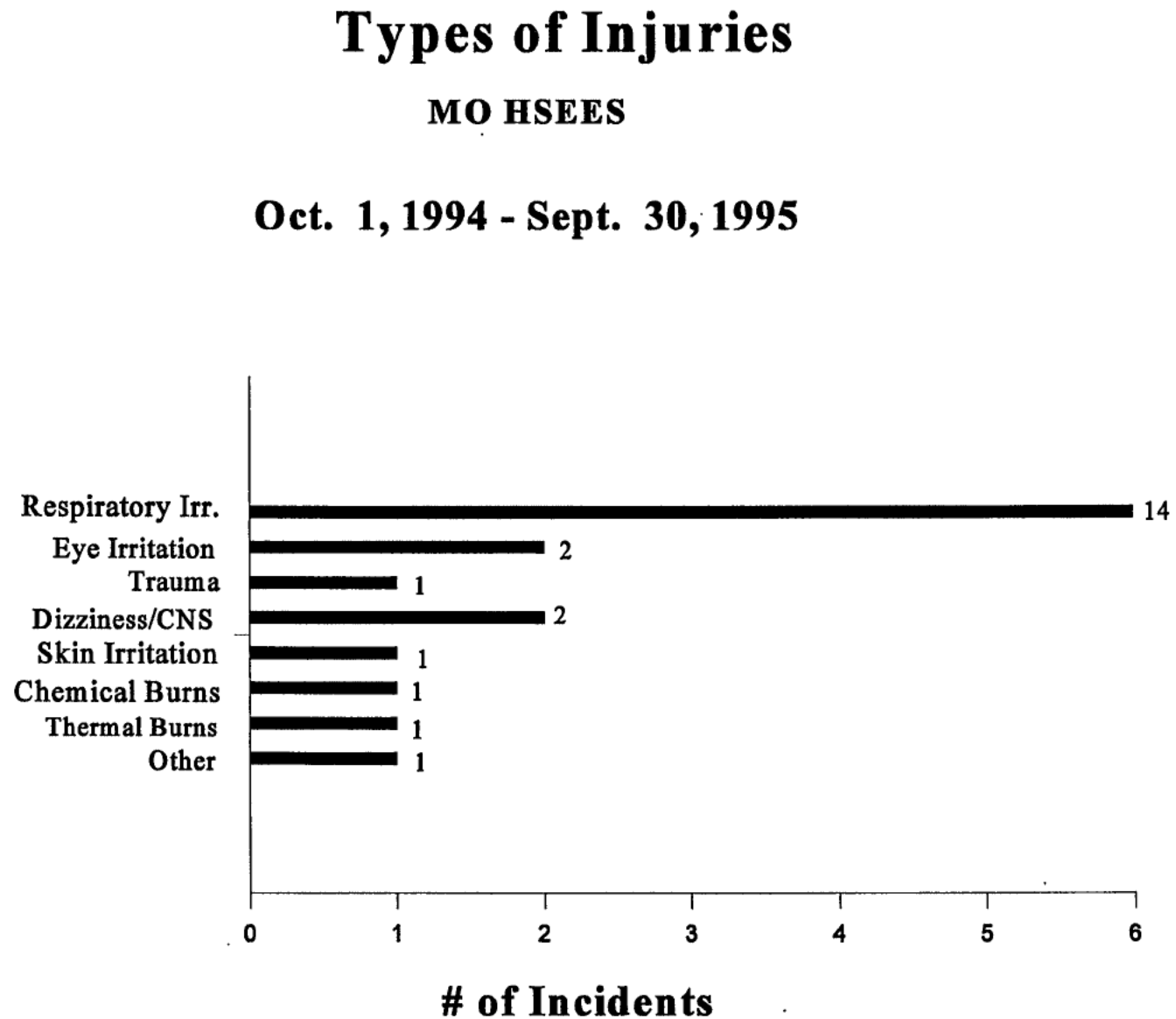
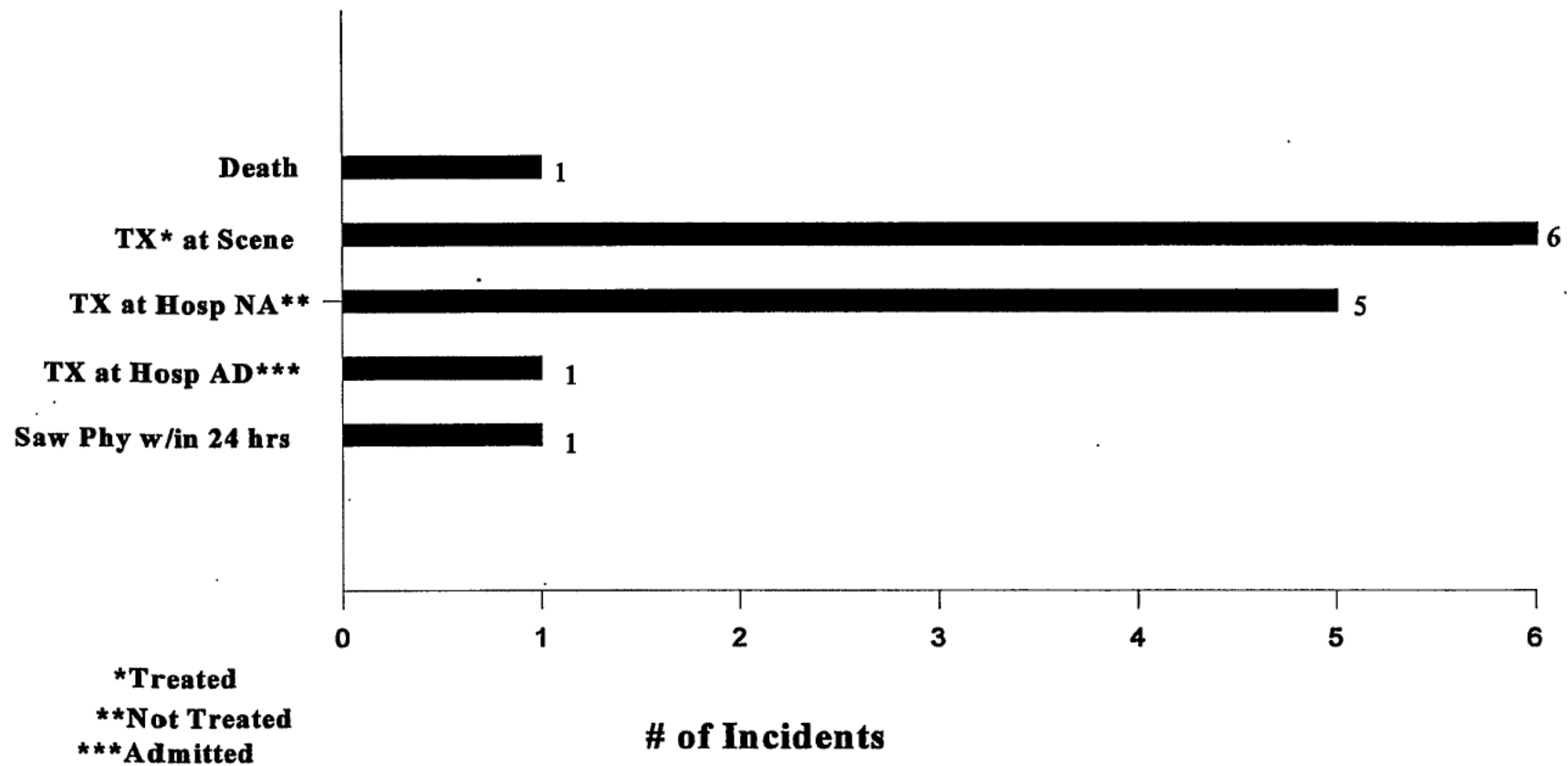


Figure 18



Severity of Injuries MO HSEES

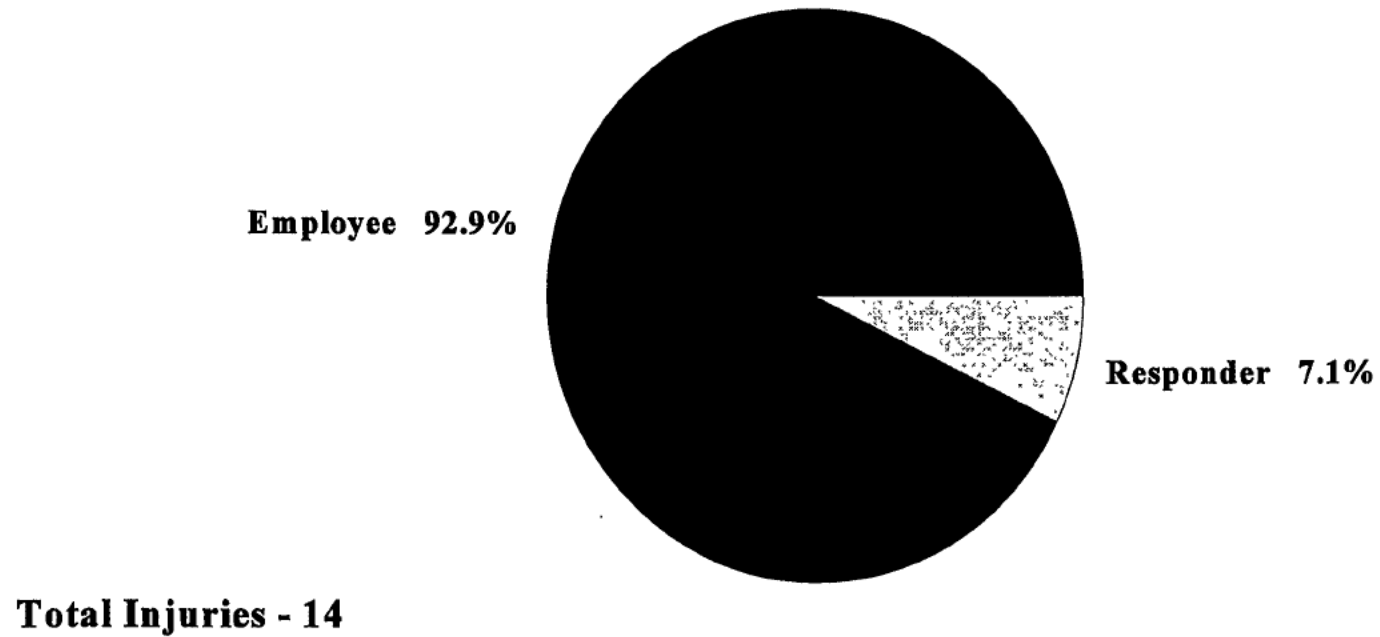
Oct. 1, 1994 - Sept. 30, 1995



Victims by Type

MO HSEES

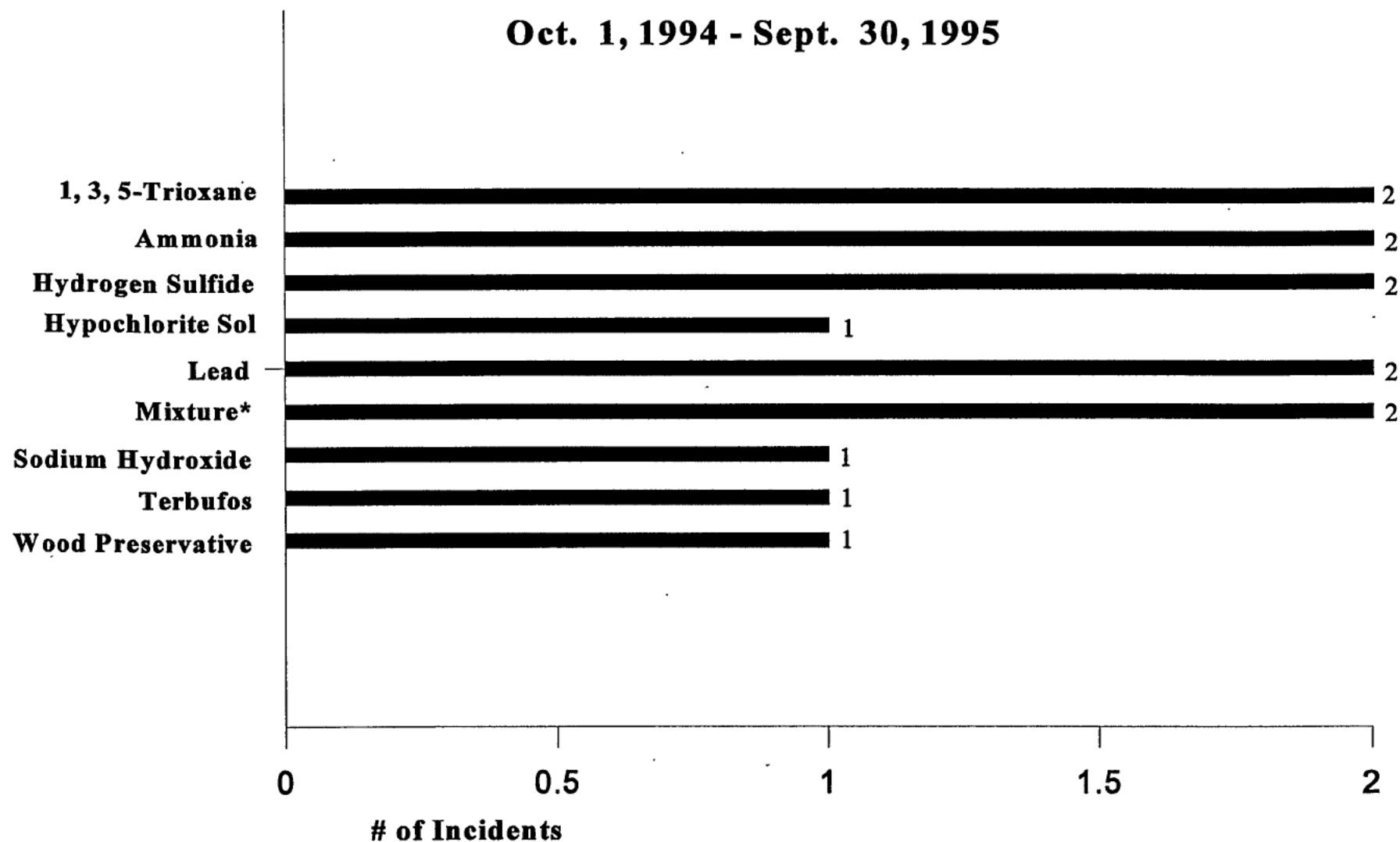
Oct. 1, 1994 - Sept. 30, 1995



Victims by Substance

MO HSEES

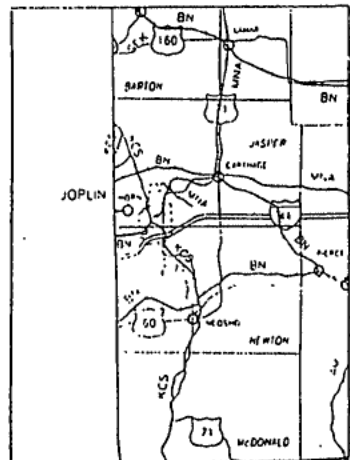
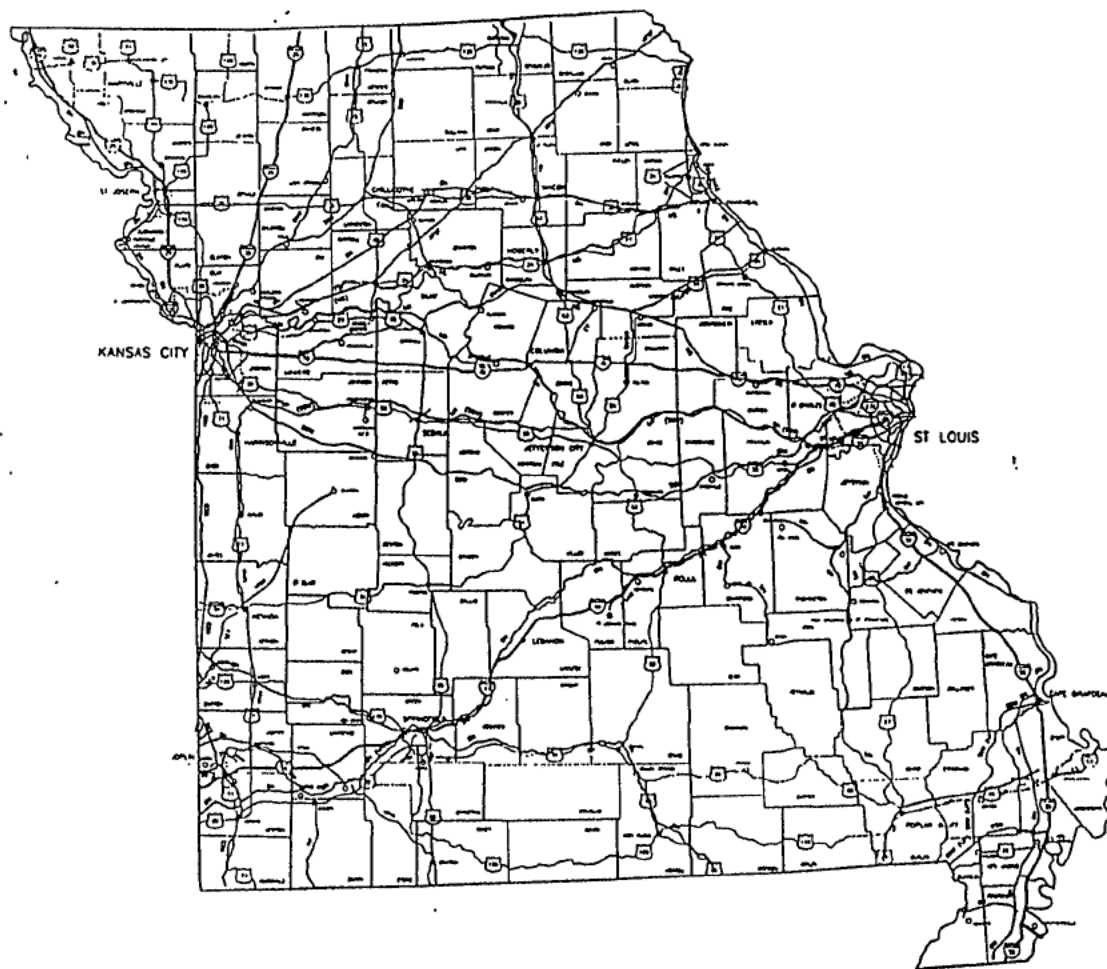
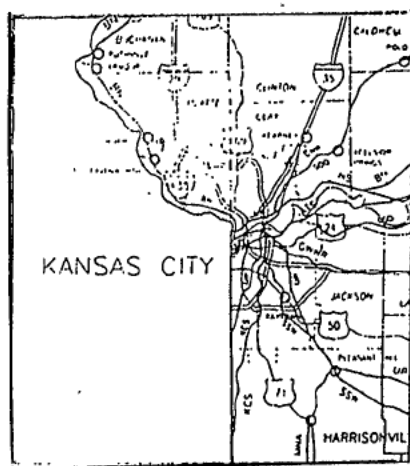
Oct. 1, 1994 - Sept. 30, 1995



*Cleaning Compound, Phosphoric Acid & Sodium Hydroxide were all released in the same event

Figure 22

MISSOURI RAIL SYSTEM



RAILROAD LEGEND

AM	Arkansas & Missouri Railroad
ATSF	Atchison, Topoka and Santa Fe Railway
BN	Burlington Northern Railroad
CBRM	Chillicothe-Brunswick Rail Maintenance Auth
CNW	Chicago & North Western Railway
CT	Columbia Terminal Railroad
GWWR	Gateway Western Railway
KCS	Kansas City Southern Railway
KCT	Kansas City Terminal
MNA	Missouri & No. Arkansas Railroad
NS	Norfolk Southern Railway
SEK	Southeast Kansas Railroad
SOO	Soo Line Railroad
SSW	St Louis Southwestern Railway
TRRA	Terminal Railroad Assoc. of St. Louis
UP	Union Pacific Railroad
USAR	U.S. Army Railroad
WAFB	Whiteman Air Force Base
SHRX	Smoky Hill Railway
SLOI	St Louis Iron Mountain

 Class I Railroads
 Regional/Short Line Railroads

Figure 23

EPA List of Top ten facilities that release toxic chemicals in Missouri (1995)

(All figures are in pounds)

FACILITY	COUNTY	AIR	WATER	LAND	TOTAL
Doe Run Company	Jefferson	236,823	1,070	7,868,740	8,106,633
Asarco, Inc.	Iron	391,398	44	6,134,355	6,525,797
Ford Motor Company	Clay	2,160,536	0	0	2,160,536
Mo. Chemical Works	Pike	2,081,760	0	0	2,081,760
Ford Motor Company	St. Louis	2,056,688	0	0	2,056,688
Dow Chemical Co.	Jefferson	1,769,591	0	0	1,769,591
AG Processing Inc.	Buchanan	1,072,470	5	0	1,072,475
Dyno Nobel Inc.	Jasper	1,165	1,003,280	0	1,004,445
Dyno Nobel Inc.	Pike	194,800	783,000	0	977,800
ICI Explosives USA Inc	Jasper	297,465	676,750	0	974,225

Note: Missouri had no releases in 1995 through underground injection.

EPA List of Top Five Chemicals in Missouri for Total Releases in 1995

(All figures are in pounds)

CHEMICAL	AIR	WATER	LAND	TOTAL
Zinc Compounds	164,995	954	6,172,605	6,338,554
Xylene (mixed isomers)	4,895,624	0	250	4,895,934
Zinc (fumes or dust)	10,947	12	4,250,259	4,261,218
Methyl ethyl ketone	2,968,234	500	0	2,968,734
a-Hexane	2,956,701	0	0	2,956,701

MASS TRANSPORTATION ACCIDENTS

I. TYPE OF HAZARD

Mass Transportation Accident

II. DESCRIPTION OF HAZARD

For the purpose of this study, mass transportation is defined as the means, or system, that transfers larger groups of individuals from one place to another. The important key is that we are discussing transportation accidents involving the public, not materials. Thus, mass transportation accidents include public airlines, railroad passenger cars, metro rail travel, tour buses, city bus lines, school buses, riverboat casinos, and other means of public transportation.

The State of Missouri serves as a crossroad for the United States. Missouri, being centrally located in the nation, is naturally a hub for most major airlines and other types of tourist and business travel. Many cross country travelers use Missouri terminals to connect with transport changes for the next leg of their journey. Our airways, railways and highways are used for non stop thorough fare as well.

In 1993, Missouri's largest city, St. Louis, began operating a MetroLink rail transportation system. St. Louis is located on the eastern boundary of this state. Before service began, ridership was projected at 12,000 per day. In August 1993, the system's first month of operation between 20,000 and 35,000 rode the MetroLink each day. In July 1994, the average weekday ridership topped 42,000 commuters. MetroLink carried nearly 9 million customers during its first year of operation. The largest number of people are transported during the morning and evening rush hours.

Amtrack, the state's major passenger rail carrier, utilizes tracks that cross the entire state, East to West. Though Amtrak has experienced a decline in passengers during this decade, it continues to carry a large number of passengers daily. The peak period is close to holidays or special events.

Branson, which is located close to the state's southwestern border, has become one of this state's major tourist attractions. It ranks high among the nations top attractions. By the year 2000, this area expects to attract more than ten million tourists yearly. Because Branson is a small community, tourists are more visible than in Kansas City and St. Louis. As well, there are fewer resources (number of hospital beds, fire equipment, ambulances, etc.) in a small community.

III. HISTORICAL STATISTICS

Commercial motor vehicles were involved in a significant number of Missouri traffic accidents. In 1993, 9.1% of all traffic accidents involved a commercial motor vehicle. Of fatal traffic accidents, 15.9% involved a commercial motor vehicle. A total of 155 persons were killed and 5,615 were injured in commercial motor vehicle related accidents.

Although school buses are not involved in a large number of traffic accidents in the state, they are important due to their potential for causing death and injury to young children. Of all 1993 Missouri traffic accidents, 0.9% involved a school bus or a school bus signal. A total of five persons and 784 were injured in these accidents.

Tour buses are on the increase. With Branson continuing to expand, more bus traffic can be expected. In 1993, a total of four deaths and 311 injuries occurred in bus related accidents.

IV. MEASURE OF PROBABILITY AND SEVERITY

A major accident could occur even though all safety precautions are in place. **Based on the information in the Missouri 1994 Edition of Traffic Crashes, the probability and severity of a mass transportation accident is rated as moderate.**

V. IMPACT OF THE HAZARD

A mass transportation accident could burden a local jurisdiction's available medical services. Mutual aid agreements with adjoining jurisdictions should be developed between ambulance services and the hospitals.

VI. SYNOPSIS

This type of hazard could involve hazardous materials or a fire which would compound the incident. Severe weather could also hamper response efforts.

VII. MAPS OR OTHER ATTACHMENTS

For additional information, see Traffic Crashes - Missouri 1994 edition, and 1993 Missouri Traffic Safety Compendium, which both can be obtained from the Missouri State Highway Patrol and the Division of Highway Safety.

The Missouri Gaming Commission, in conjunction with the State Emergency Management Agency, is working on the development of emergency planning procedures for riverboat casinos.

CIVIL DISORDER

(TO BE DEVELOPED)

TERRORISM

I. TYPE OF HAZARD

Terrorism

II. DESCRIPTION OF HAZARD

Terrorism, as defined by the Federal Bureau of Investigation (FBI), includes: “the unlawful use of force or violence, committed by a group(s) of two or more individuals, against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives.”

According to the FBI, there are two types of terrorism:

1. Domestic Terrorism--involves groups or individuals whose terrorist activities are directed at elements of our government or population without foreign direction.
2. International Terrorism--involves terrorist activity committed by groups or individuals who are foreign-based and/or directed by countries or groups outside the United States or whose activities transcend national boundaries.

Forms of Terrorism

Terrorism can take place in various forms, depending on the technological means available to the terrorist group, the nature of the political issue motivating the attack, and the points of weakness of their target. Potential terrorist actions include:

- Bombings--large scale, such as the Oklahoma City bombing, or small-scale, such as a letter bomb.
- Airline attacks--bomb on board, such as the Pan Am Flight 103 over Lockerby, Scotland, a surface-to-air missile attack, or a hijacking.
- Nuclear/Biological/Chemical attacks--nuclear or biological weapons may get into the hands of terrorists, as well as chemical materials, such as the sarin gas attack in the Tokyo Subway Station.
- Infrastructure attack--Amtrak Train derailment in Arizona, contamination of drinking water, and electronic sabotage (such as computer viruses which could dismantle our financial institutions or even our air traffic control systems).
- Arson--recent outbreak of church burnings. (Although Missouri has experienced 15 deliberately-set fires, none have been determined to be terrorist or hate-crime related.)
- Kidnappings/Assassinations--since these are generally against specific individuals, their effect on emergency management operations may be minimal in terms of response.

Domestic Terrorism Trends

According to the FBI, the following trends have been observed regarding domestic terrorism:

1. **Special Interest Terrorism**--groups that seek specific issue resolutions rather than widespread political changes. Their causes may or may not be criminal, but the means they use are.

Examples of this type of terrorist group include the Animal Liberation Front, Up the IRS, and the Earth Night Action Group. Another group that the FBI is now investigating for conspiracy is the anti-abortion groups. If the FBI is able to prove that a national conspiracy exists among these perpetrators, they could be prosecuted under domestic terrorism laws.

2. **Right-Wing Terrorism**--groups that are racist, anti-black, anti-Semitic, and for the advancement of the white race.

Examples of this type of group include Aryan Nations, the Order, and Posse Comitatus. Many of these groups are also classified as "extremist groups." Missouri has seen some activity from these groups in the past few years. According to the Southern Poverty Law Center, Missouri has 27 extremist groups operating within its borders. Although Missouri also has a state statute against paramilitary training, one of these groups is known to have such a facility. Also, several gatherings of extremist groups have taken place within the state in recent years.

3. **Left-Wing Terrorism**--groups that are Marxist-Leninist in orientation.

Examples of this type of terrorist group include the Armed Forces of National Liberation and the Macheteros (both from Puerto Rico), the African National Ujammu, the AnSaru Allah Community, the Dar-UI Movement, and the United Freedom Front.

International Terrorism Trends

The United States was able to enjoy eleven years straight without having an act of international terrorism take place on our soil. However, this existence soon came to an abrupt end with the bombing of the World Trade Center in 1993 by international terrorists.

III. HISTORICAL STATISTICS

Missouri

The State of Missouri has experienced very few terrorist acts. In 1989, two brothers from St. Louis, along with a man from Milwaukee, Wisconsin, pled guilty to felony racketeering charges for

conspiring to participate in the terrorist organization known as the Abu Nidal Organization (ANO). Charges against a fourth defendant were dropped since he was on death row in a Missouri correctional facility for the murder of his daughter.

A suspected incidence of terrorism occurred in 1994, when a Missouri State Highway Patrolman was shot at his home by a sniper. The trooper survived the incident. The shooting was believed to be in retaliation for a raid on the Citizens for the Kingdom of Christ compound. The alleged sniper remains at large.

In January 1996, a man from Bonner Springs and connected with the Missouri 51st Militia, was charged with criminal use of explosives. An explosive device, gun powder, an assault rifle, a handgun, manuals to make explosives and booby traps, and a detailed floor plan of a building used to hold federal prisoners in Oklahoma City were found at the defendant's home.

United States

Overall for 1995, (according to the FBI) the United States experienced one actual act of terrorism, one suspected incident, and two prevented acts of terrorism. The one actual terrorist act occurred on April 19th, with the bombing of the Alfred P. Murrah Federal Building in Oklahoma City. That bombing killed 168 people and injured 518 others, making it the worst terrorist attack on U.S. soil. Two defendants are currently awaiting trial for terrorism, murder, and conspiracy and could receive the death penalty if convicted.

The one suspected terrorist incident involved the derailment of the Amtrak Sunset Limited passenger train near Hyder, Arizona. One person was killed and 83 others were injured in this incident. The train track had been sabotaged, causing the train to jump the tracks and topple 30 feet from a bridge. A letter signed by the Sons of Gestapo was left at the scene. No arrests have been made in the case.

The first of the two prevented terrorist incidents occurred in March. Four members of the Minnesota Patriots Council were convicted of conspiracy to produce and possess ricin, one of the deadliest known toxins. This chemical was to be used to kill law enforcement officers and Internal Revenue Service agents.

The other prevented act of terrorism involved the Tri-States Militia (a group composed of militia from at least 30 states). Members of this group were arrested after being linked to five would-be terrorists whose bomb plots were thwarted by federal and state law enforcement agencies. The plots involved blowing-up the Southern Poverty Law Center, offices of the Anti-Defamation League, federal buildings, abortion clinics, and gay community locations.

More recently, the Olympic Park bombing in Atlanta and the downing of TWA Flight 800, both of which occurred in July 1996, are two incidents yet to be determined if terrorism was involved.

IV. MEASURE OF PROBABILITY AND SEVERITY

Probability

Although this state has identified several different extremist groups operating here, there have been no indications of any specific terrorist activities. The potential does remain for some new extremist and/or terrorist group to move into the state.

An open society such as ours, which is dependent upon technology for its continued smooth operation, remains a potential target for terrorists. Large cities with a variety of news media outlets would be the most likely locations for terrorist acts. Some terrorists want their acts to reverberate in the news media and reach the largest audience possible. Since Missouri does not have large media markets when compared to the larger metropolitan states, it is not as likely a target for terrorist activity. However, after the Oklahoma City bombing, the theory that rural America is safe from terrorists has been shattered.

With this in mind, it appears that a terrorist attack could occur in Missouri, but the probability of such an attack is low.

Severity

Should Missouri experience a terrorist attack, the severity of such an attack could range from high to low, depending on the attack. For instance, if a building was blown-up and no lives were lost, the severity of the attack would be low. However, if a terrorist group decided to contaminate a large urban area's water supply with a poisonous chemical, the severity of the attack could be very high due to the number of people directly affected from the poisoned water, as well as the damage that was done to that community's sense of well-being. An attack of this nature would easily result in mass hysteria and insecurity in the government's ability to protect its citizens.

V. IMPACT OF THE HAZARD

As stated above, terrorist acts could easily undermine the confidence that people have in their own security and that of their government's ability to protect them from harm. For example, the ability to make bombs is accessible to a potential terrorist since instructions can be obtained from many sources, such as the Internet, and the materials are readily available. Since bombs can be made so easily, the threat of a bomb is not taken lightly. Even the threat of a bomb can disrupt a community almost as effectively as an actual bomb, while creating far fewer risks for the person(s) making the threat. Therefore, no matter how large or small the incident, a terrorist act can have a major impact on a community.

VI. SYNOPSIS

There are many ways a terrorist can attack a society. Therefore, it is of utmost importance for people to be prepared as much as possible should they be threatened by or become involved in such an incident. The following guidelines from the Federal Emergency Management Agency should be used:

Before

Learn about the Nature of Terrorism:

- Terrorists often choose targets that offer little danger to themselves and areas with relatively easy public access.
- Foreign terrorists look for visible targets where they can avoid detection before or after an attack, such as international airports, large cities, major international events, resorts, and high-profile landmarks.

Learn about the different types of terrorist weapons, including explosives, kidnappings, hijackings, arson, and shootings.

Prepare to deal with a terrorist incident by adapting many of the same techniques used to prepare for other crises.

- Be alert and aware of the surrounding area. The very nature of terrorism suggests that there may be little or no warning.
- Take precautions when traveling. Be aware of conspicuous or unusual behavior. Do not accept packages from strangers. Do not leave luggage unattended.
- Learn where emergency exits are located. Think ahead about how to evacuate a building, subway, or congested public area in a hurry. Learn where staircases are located.
- Notice your immediate surroundings. Be aware of heavy or breakable objects that could move, fall, or break in an explosion.

Preparing for a Building Explosion:

The use of explosives by terrorists can result in collapsed buildings and fires. People who live or work in a multi-level building can do the following:

- Review emergency evacuation procedures. Know where fire exits are located.
- Keep fire extinguishers in working order. Know where they are located and how to use them. Learn first aid. (Contact the local chapter of the American Red Cross for additional information.)

- Keep these items in a designated place on each floor of the building--1) portable battery-powered radio and extra batteries, 2) several flashlights and extra batteries, 3) first aid kit and manual, 4) several hard hats, and 5)fluorescent tape to rope-off dangerous areas.

Bomb Threats:

If you receive a bomb threat, get as much information from the caller as possible. Keep the caller on the line and record everything that is said. Notify the police and the building management.

After you have been notified of a bomb threat, do not touch any suspicious packages. Clear the area around the suspicious package and notify the police immediately. When evacuating a building, avoid standing in front of windows and other potentially hazardous areas. Do not block sidewalks or streets that will be used by emergency officials.

During

In a building explosion, get out of the building as quickly and calmly as possible.

If items are falling off of bookshelves or from the ceiling, get under a sturdy table or desk.

If there is a fire:

- Stay low to the floor and exit the building as quickly as possible.
- Cover nose and mouth with a wet cloth.
- When approaching a closed door, use the palm of your hand and forearm to feel the lower, middle, and upper parts of the door. If it is not hot, brace yourself against the door and open it slowly. If it is hot, do not open the door--seek an alternate escape route.
- Heavy smoke and poisonous gases collect first along the ceiling. Stay below the smoke at all times.

After

If you are trapped in debris:

- Use a flashlight.
- Stay in your area so that you do not kick-up dust. Cover your mouth with a handkerchief or clothing.
- Tap on a pipe or wall so that rescuers can hear where you are. Use a whistle if one is available. Shout only as a last resort--shouting can cause a person to inhale dangerous amounts of dust.

Assisting victims:

- Untrained persons should not attempt to rescue people who are inside a collapsed building. Wait for emergency personnel to arrive.

Chemical and Biological Agents

Chemical Agents:

- Chemical agents are poisonous gases, liquids, or solids that have toxic effects on people, animals, and plants. Most chemical agents cause serious injuries or death.
- The severity of injury depends on the type and amount of the chemical agent used and the duration of exposure.
- Should a chemical agent attack occur, authorities would instruct citizens to either seek shelter where they are and seal the premises or evacuate immediately. Exposure to chemical agents can be fatal. Leaving the shelter to rescue or assist victims can be a deadly decision. There is no assistance that an untrained person can offer that would likely be of any value to the victims of chemical agents.

Biological Agents:

- Biological agents are organisms or toxins that have illness-producing effects on people, animals, and plants.
- Since biological agents cannot necessarily be detected and may take time to grow and cause a disease, it is almost impossible to know that such an attack has occurred. If government officials become aware of a biological attack through an informant or a warning by a terrorist, they would most likely instruct citizens to either seek shelter where they are and seal the premises or evacuate immediately.
- A person affected by a biological agent requires the immediate attention of professional medical personnel. Some agents are contagious and victims may need to be quarantined. Also, some medical facilities may not receive victims for fear of contaminating the hospital population.

VII. MAPS OR OTHER ATTACHMENTS

None.

**ATTACK
(NUCLEAR, CONVENTIONAL,
CHEMICAL, AND BIOLOGICAL)**

I. TYPE OF HAZARD

Attack

(Nuclear, Conventional, Chemical, and Biological)

II. DESCRIPTION OF HAZARD

Of all the possible disasters and hazards we can imagine, strategic nuclear, chemical or conventional attack would be the most devastating and far-reaching in its consequences. The use of these weapons against the United States is unlikely. Unfortunately, however, as long as such weapons exist there is always the chance that they could be used.

Although the threat of all-out nuclear war has been significantly reduced with the dissolution of the Soviet Union, several scenarios still exist that might subject a jurisdiction to widespread radioactive contamination and/or high level radiation exposure. Government officials and other decision makers must remember that the terms of the START II Treaty, when fully complied with at the end of ten (10) years from its signing, still allows its signatories, Russia and the United States, to maintain one thousand (1000) nuclear weapons each.

Additionally, we are reminded there are nearly twenty (20) other sovereign nations who either now have or are on the verge of developing their own nuclear capability (according to testimony of James Woolsey, CIA Director, of the Senate Foreign Affairs Committee, February, 1994). Also, no one can deny the instability of the Korean peninsula.

III. HISTORICAL STATISTICS

During World War I, chemical and conventional weapons were used.

During World War II, atomic (nuclear), chemical and conventional weapons were used.

During the Korean conflict and Vietnam War, chemical and conventional weapons were used.

IV. MEASURE OF PROBABILITY AND SEVERITY

A single nuclear weapon detonation would cause massive destruction and all three types of attacks could cause extensive casualties. An all-out nuclear attack would affect the entire population. Some areas would experience direct weapons effects: blast, heat, and initial nuclear radiation. Most other areas would experience indirect weapons effects, primarily radioactive fallout.

There have been no attacks; and as long as world leaders maintain rational thinking, the probability remains low.

Secondary effects of these attacks which could severely stress the country are lack of adequate shelters, food, water, health and medical facilities, and/or personnel, mortuary services, disruption of communication systems, and power outages. **Therefore, the severity of these attacks is rated high.**

V. IMPACT OF THE HAZARD

The population is vulnerable to two separate types of effects associated with the detonation of nuclear weapons. These threats are defined as:

Direct Effects: The effects directly associated with the detonation of the weapon. These are heat, blast, and high intensity nuclear radiation. These effects will generally be limited to the immediate area of the detonation, i.e., up to 22 miles depending upon weapon size, altitude of burst, and atmospheric conditions.

Indirect Effects: Any effect not directly associated with the detonation of the weapon. These effects are generally limited to radioactive fallout, and can be widespread geographically of varying time limits and intensities, depending on weapon size, altitude of burst, and wind patterns. After a major attack, all areas of the country would probably be subjected to some level of fallout.

When a nuclear weapon explodes, it produces intense heat and a blast wave similar to a tidal wave of air. The blast wave is measured in pounds per square inch (psi) overpressure. The greater the psi, the greater the threat to people.

Another effect of nuclear weapons is radioactive fallout. If a nuclear weapon explodes near or on the ground, it sucks up large quantities of earth and debris into a mushroom cloud. This material becomes radioactive, and the particles can be carried by the winds hundreds of miles before they drop back to earth as "fallout." In an attack, many areas of the United States would probably escape fallout altogether or experience non-life-threatening levels of radiation. However, because of the unpredictability of the weather, which determines where fallout will land, *no* locality in the United States can be said to be free from the risk of receiving deadly levels of radiation in the event of a strategic attack.

For chemical weapons, the direct effects are initial spread of chemicals and fragmentation of the weapon. Indirect effect are generally limited to downwind hazard areas and can be widespread geographically of varying time limits and intensities, depending on weapon size, type of chemical and wind patterns.

VI. SYNOPSIS

Even though the START treaty has reduced the overall number of nuclear weapons and that the chemical weapons stockpiles are scheduled to be destroyed, we must not allow ourselves to be lulled into a sense of security that this threat no longer matters. We must continue to plan for and be prepared for this type of hazard.

VII. MAPS OR OTHER ATTACHMENTS

No attachments or maps available.

BIBLIOGRAPHY

TORNADOES/SEVERE THUNDERSTORMS

Statistics: National Weather Service (NWS), Tornadoes, Death and Injury Statistics, 1950-1996; NWS (Severe Weather Death and Injury Statistics, 1992-1996; Disaster Declarations For Missouri Tornadoes Since 1975, State Emergency Management Agency.

FLOODS (MAJOR AND FLASH)

Publications: After Action Report, The 1995 Missouri Flood, State Emergency Management Agency (SEMA); The Response, Recovery and Lessons Learned from the Missouri Floods of 1993 and 1994 (SEMA); The Floods of '93, State of Missouri, Interagency Hazard Mitigation Team Report (April 1993); Missouri Water Atlas, MO Dept. of Natural Resources (1986); Flash Floods and Floods, A Preparedness Guide, U.S. Dept. of Commerce, NOAA (July 1992).

Statistics: State Emergency Management Agency (Floods of '93-'95; Disaster Declarations, 1993-1995); Missouri Dept. of Health (Flood Mortality, Summer-Fall 1993); National Weather Service (Severe Weather Death and Injury Statistics, 1992-1996).

Illustrations: Record High Water Stages, Distribution Of Levee Failures, U.S. Army Corps of Engineers (1993); Flood Mortality Statistics, Summer/Fall 1993, Missouri Department of Health; Maps, Spring, Summer, and Fall '93 Floods; Spring '94 Flood, and Spring '95 Flood (Counties/Cities Declared), State Emergency Management Agency.

SEVERE WINTER WEATHER (SNOW, ICE, EXTREME COLD)

Publications: Hypothermia Mortality in Missouri 1984-1994, Missouri Department of Health

DROUGHT

Publications: Missouri Drought Response Plan, State Water Plan (1995), Missouri Department of Natural Resources, Division of Geology and Land Survey, P.O. Box 250, Rolla, MO 65401; Missouri Weather Patterns and Their Impact on Agriculture (Grant L. Darkow, Department of Atmospheric Science), University of Missouri Extension, Columbia, MO.

Illustrations: Palmer Drought Severity Index, Missouri Subregions; Drought Susceptibility Map, Dept. of Natural Resources, Missouri Drought Response Plan.

HEAT WAVE

Publications: Heat Wave Preparedness Task Force, Preliminary Report (Heat Waves in Pennsylvania, August 1993).

Statistics: Local Climatological Data, 1993 Annual Summary With Comparative Data, National Weather Service, Kansas City, Columbia, Springfield, and St. Louis, MO offices; Missouri Department of Health, Office of Epidemiology, Jefferson City, MO.

Illustrations: Heat Related Deaths, 1911-1990; Missouri Heat Related Illnesses, Summer 1991-1994, Missouri Department of Health.

EARTHQUAKES

Publications: Atkinson, William. The Next New Madrid Earthquake, Carbondale, Illinois: Southern Illinois University Press, 1989.

Bolt, Bruce, A. Earthquakes, 2d ed. New York: W.H. Freeman, 1988.

Fuller, Myron L. The New Madrid Earthquake, Washington: Government Printing Office, 1912. Reprinted by Southeast Missouri State University, 1989.

Hughes, E.A. Safety Overrides All Nuclear Concerns, Electric World, March 1, 1976.

Nuttli, Otto W. The Effects of Earthquakes in the Central United States, Marion, Illinois: Central United States Earthquake Consortium, 1987. Reprinted by Southeast Missouri State University, 1990.

Morgan, Lael. Earthquake Survival Manual, Seattle: Epicenter Press, 1993.

Penick, James Lal, Jr. The New Madrid Earthquakes, Columbia, Missouri: University of Missouri Press, 1981.

Stewart, David M., and Ray B. Knox. The Earthquake That Never Went Away, Marble Hill, Missouri: Gutenberg-Richter Publications, 1993.

Stewart, David M. Damages & Losses From Future New Madrid Earthquakes, Cape Girardeau: Southeast Missouri State University, 1994.

Illustrations: Projected Earthquake Intensities (Figure 1), State Emergency Management Agency (SEMA); Moderate/Large Earthquakes, Central United States (Figure 2), SEMA; New Madrid Seismic Zone, Magnitude 7.6 Earthquake, Estimated Deaths and Serious Injuries (Figure 3), Damage Costs (Figure 4), Deaths (Figure 5), Serious Injuries (Figure 6), Dollars (Millions) to Replace Buildings (Figure 7), and Dollars Damage to Utilities (Figure 8), Central United States Earthquake Intensity Scale, Center for Earthquake Studies, Southeast Missouri State University, Cape Girardeau, Missouri.

DAM FAILURE

Publications: Missouri Department of Natural Resources, Division of Geology and Land Survey (1991) Maintenance, Inspection and Operation of Dams in Missouri; (1980) Inventory of Non-Federal Dams in Missouri; (1995) Inventory of Dams in Missouri compiled by DNR, Division of Dam Safety, Rolla, MO.

Illustrations: Figure 1 (Observable Defects); DNR, Maintenance, Inspection and Operation of Dams in Missouri; Table (Dams in Missouri by Purpose); Water Control Infrastructure, National Inventory of Dams, 1992, Volume II, U.S. Army Corps of Engineers, FEMA 246/October 1993; List of Missouri Dams by County, 1995 Inventory of Dams, DNR, Division of Dam Safety, Rolla, MO.

UTILITIES (INTERRUPTIONS AND SYSTEM FAILURES)

Statistics: Missouri Public Service Commission

FIRES (STRUCTURAL, URBAN, AND WILD)

Statistics: 1993 Missouri Incident Reporting System

NUCLEAR POWER PLANTS (FIXED NUCLEAR FACILITIES)

Statistics: U.S. Nuclear Regulatory Commission, Reactor Safety Study (WASH 1400), Washington D.C. (October 1975).

Publications: Hughes, E.A., Safety Overrides All Nuclear Concerns, Electrical World (March 1, 1976); Missouri Nuclear Accident Plan - Callaway; Missouri Nuclear Accident Plan - Cooper

HAZARDOUS MATERIALS; OTHER ENVIRONMENTAL ISSUES

Statistics: Federal Highway Administration, Department of Energy, Agency for Toxic Substances and Disease Registry (ATSDR), Missouri Department of Health, Missouri Department of Natural Resources, Missouri State Highway Patrol.

Illustrations: Hazardous Substances Emergency Events, Surveillance (HSEES) - Missouri Department of Health.

MASS TRANSPORTATION

Statistics: MetroLink Rail - St. Louis, Missouri, Amtrak, and the Missouri Traffic Safety Compendium.

Publications: Traffic Crashes - Missouri 1994 edition, Missouri Division of Highway Safety.

CIVIL DISORDERS

(TO BE DEVELOPED)

TERRORISM

Statistics: Federal Bureau of Investigation

“Church Investigations,” February 18, 1996, Missouri State Fire Marshall’s Office, Fire Investigations Unit.

Publications: “Fact Sheet: Terrorism,” July 15, 1996, www.fema.gov/terrorf.html.

False Patriots--The Threat of Anti-Government Extremists, (1996) Southern Poverty Law Center, Klanwatch Project.

Statistics: “FBI Bombing Statistics--1995,” December 9, 1996, www.fbi.gov/lab/bomsum/1995stat.htm.

Publications: “FBI Investigates Train Derailment,” October 11, 1995, Associated Press.

“Oklahoma City Tragedy,” www.cnn.com/US/OKC/bombing.html.

“Patterns of Global Terrorism--1995,” United States Department of State.

“Terrorism in the United States--1993,” United States Department of Justice, Federal Bureau of Investigation.

“Terrorism in the United States--1994,” United States Department of Justice, Federal Bureau of Investigation.

“Terrorism in the United States--1995,” United States Department of Justice, Federal Bureau of Investigation.

ATTACK (NUCLEAR, CONVENTIONAL, CHEMICAL, BIOLOGICAL)

Statistics: Federal Bureau of Investigation